ELECTRICITY

IN

MEDICINE AND SURGERY,

INCLUDING THE X RAY,

BY

WILLIAM HARVEY KING, M. D.,

EDITOR OF THE JOURNAL OF ELECTRO-THERAPEUTICS; AUTHOR OF A TEXT BOOK ON ELECTRO-THERAPEUTICS; AUTHOR OF A TREATISE ON SPERMATORRHŒA, IMPOTENCE AND STERILITY; PROFESSOR OF ELECTRO-THERAPEUTICS IN THE NEW YORK HOMŒOPATHIC MEDICAL COLLEGE AND HOSPITAL; PROFESSOR OF ELECTRO-THERAPEUTICS IN THE NEW YORK MEDICAL COLLEGE AND HOSPITAL FOR WOMEN; VISITING ELECTRO-THERAPEUTIST TO THE METROPOLITAN HOSPITAL; CONSULTING ELECTRO-THERAPEUTIST TO THE FLOWER HOSPITAL; CONSULTING ELECTRO-THERAPEUTIST TO THE NEW YORK MEDICAL COLLEGE AND HOSPITAL FOR WOMEN; MEMBER OF THE AMERICAN X RAY SOCIETY; MEMBER OF THE NATIONAL SOCIETY OF ELECTRO-THERAPEUTISTS, ETC., ETC.

IN TWO PARTS.

WITH A SECTION ON

ELECTRO-PHYSIOLOGY,

BY

W. Y. COWL, M. D.,

BERLIN, GERMANY,

ABTHEILUNGSCHEF AM INSTITUT FÜER MEDICINISCHE DIAGNOSTIK, BERLIN, PRUSSIA; ASSISTENT AM PHYSIOLOGISCHEN INSTITUT DER UNIVERSITAET, BERLIN.

AND A SECTION ON THE

BOTTINI OPERATION,

BY

ALBERT FREUDENBERG, M. D.,

BERLIN, GERMANY,

GENITO-URINARY SURGEON.

NEW YORK.

BOERICKE & RUNYON CO.

1901.

T. B. & H. B. COCHRAN,
PRINTERS,
LANCASTER, PA.

PREFACE.

To make this treatise a thorough and reliable work on the use of electricity in medicine and surgery, has been the one constant aim of the author from the beginning to the finish. While nearly every country and language has contributed to its pages, the author has, nevertheless, at all times, been guided in the selection or rejection of material and in statements as to facts, by his own knowledge of the therapeutic use of electricity. While he has endeavored to hold the book within a reasonable size, he has, at the same time, tried to give with sufficient detail all that is at present well established on the subject of electricity in medicine and surgery, so far as he has intended to cover the subject.

Diseases of the eye and ear have become such exclusive specialties that they have been omitted in this work.

The therapeutic action of the electric light has not been included, as the author does not consider that he has had sufficient experience in that field to pass judgment on the various claims made for it.

The author takes pride in the two sections which have been contributed to these pages by distinguished foreigners. Dr. Cowl is peculiarly fitted to write on electro-physiology. His untiring labors in physiological research have given him a mastery to which few have attained on this subject. Much of the material contained in his article is the result of special experimentation which has been carried on for the last eighteen months.

While Dr. Freudenberg was not the originator of the Bottini operation, he may justly claim, that, by a development of technic and an improvement of armamentarium, he

has made the operation the grand success it is to-day. His article in this volume is the most complete extant; the writer stating in his letter accompanying the manuscript, that it contains all that is worth writing on the subject.

The author wishes to acknowledge the services of Mr. Thomas Livingston for many of the drawings in the work, and for other services rendered, and also of Dr. Hills Coles for research in French journalistic literature. He also wishes to acknowledge his very great indebtedness to his business associate, Dr. W. H. Dieffenbach, who has been indefatigable in his research into foreign literature; from the numerous translations he has made, new facts and new ideas have been obtained and incorporated into these pages.

New York, July 4, 1901.

TABLE OF CONTENTS.

PART ONE.

SECTION ONE.

ELECTRO-PHYSICS.

SECTION TWO.

THE X RAY.

SECTION THREE.

MOTOR POINTS.

SECTION FOUR.

ELECTRO-DIAGNOSIS.

SECTION FIVE.

ORGANIC-ELECTROLOGY.

LIST OF ILLUSTRATIONS.

PART ONE.

TABLE OF CONTENTS.

PART TWO.

SECTION ONE.

GENERAL ELECTRO-THERAPEUTICS.

SECTION TWO.

DISEASES OF THE NERVOUS SYSTEM.

SECTION THREE.

GYNÆCOLOGY AND OBSTETRICS.

SECTION FOUR.

DISEASES OF THE ALIMENTARY TRACT.

SECTION FIVE.

GENITO-URINARY.

SECTION SIX.

THE TREATMENT OF HYPERTROPHY OF THE PROSTATE GLAND BY THE GALVANO-CAUSTIC METHOD, AFTER BOTTINI.

SECTION SEVEN.

DISEASES OF THE NOSE AND THROAT.

SECTION EIGHT.

DISEASES OF THE SKIN.

SECTION NINE.

GENERAL DISEASES AND DISEASES NOT OTHERWISE CLASSIFIED.

LIST OF ILLUSTRATIONS.

PART TWO.

ELECTRICITY

IN

MEDICINE AND SURGERY

PART ONE.

Electro-Physics,
X Ray,
Electric-Diagnosis,
Drganic Electrology.

ELECTRICITY IN MEDICINE AND SURGERY.

SECTION ONE.

Electro-Physics.

Static Electricity.—The term static signifies in rest, and electro-statics deals with that phenomenon of electricity at rest, or held at rest by forces acting upon it in contra-distinction to dynamic electricity, which term signifies that the current is constantly flowing along the conductors.

ELECTRICITY BY FRICTION.—If a glass rod is rubbed with a piece of silk, and a pith ball be suspended near it by means of a silk thread, the ball is at once attracted towards

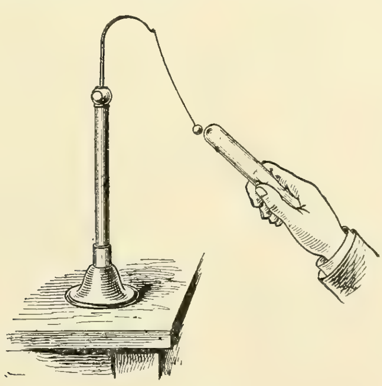


FIG. I.

the glass rod (Fig. I). This is due to the electrical state or condition of the glass which has been produced by the friction of the rubber.

ELECTRICAL ATTRACTION AND REPULSION.—If a piece of thin metal be suspended near the glass rod by means of a silk thread so as to insulate it, the rod will attract the same as it did the pith ball, but on contact just the opposite

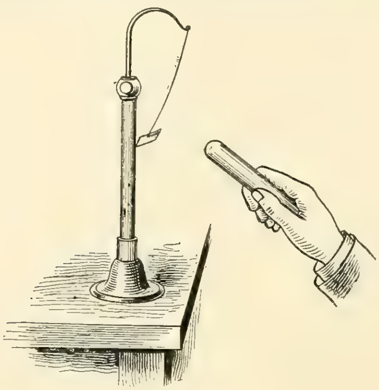


FIG. II.

takes place, the metal being at once repelled (Fig. II). If we now reverse the order and suspend the glass by a silk thread, when a piece of metal in the hand of the operator is held near

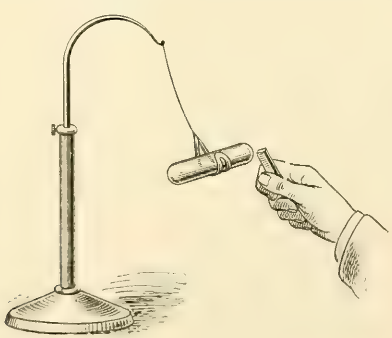


FIG. III.

(Fig. III), the glass will be attracted toward it until they touch; then, if the experimenter be thoroughly insulated, it will be repelled, thus showing that the power of attraction and repulsion is not exerted by the electrified body alone, but that it

may be itself attracted and repelled by non-electrified bodies held near it. It appears, then, that so long as a non-electrified body is near an electrified body it is attracted by it and also attracts the electrified body, but as soon as they touch and the non-electrified body is electrified, they repel one another.

The fact that a non-electrified body becomes electrified by contact is proved when another non-electrified body is held near it, and, proper precautions having been taken to insulate it to prevent the escape of the electrical charge, it is attracted and repelled in the same manner as when the electrified glass rod was used.

Electrified bodies, however, do not always repel each other, for if a stick of sealing wax be rubbed with a woolen cloth, and presented to an electrified body which has touched and is consequently electrified by the glass rod, it will be found they attract each other; or if the stick of sealing wax and a glass rod, after being excited by rubbing with silk, be suspended by silken threads, they will attract each other. (Fig. IV.)

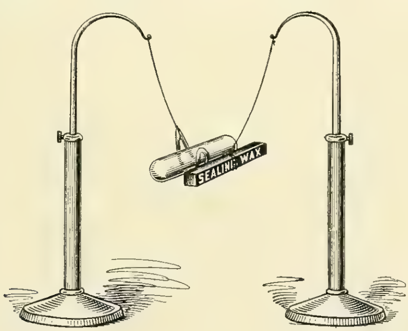


Fig. IV.

This phenomenon of attraction and repulsion was first thought to be due to two kinds of electricity, described as two electric fluids, and it was believed that bodies electrified by the same kind repelled each other, while bodies electrified by different kinds attracted each other. The supposed different kinds of electricity were given different names; that produced by rubbing glass with silk was called vitreous electricity, and

that produced by rubbing sealing wax, shellac, etc., with wool was called resinous electricity. These terms were based upon the erroneous supposition that no other kind of electricity could be produced on these substances, but it was afterwards discovered that if glass was rubbed with a catskin it produced resinous electricity, and resin yields vitreous electricity when rubbed with an amalgam of tin and mercury spread on leather.

POSITIVE AND NEGATIVE ELECTRICITY.—Franklin suggested the one fluid theory, and the terms positive and negative electricity to distinguish the two electrical states, in place of vitreous and resinous, and they are still in use. These terms were based upon the theory that all objects possess a certain amount of electricity, and that a body charged positively, such as a glass rod rubbed with silk, and which was known as vitreous electricity, possesses a greater amount than when in a normal state, and that a body negatively charged possesses a less amount of electricity than when in a normal state. From this supposition arose the signs which are still used to designate the two electrical states or poles of the battery, the plus sign (+) for the positive and the minus sign (—) for the negative.

We know now that positively and negatively charged bodies do not actually attract one another, but that they produce certain changes in the medium between them, and that they are drawn toward each other by the stress of this intervening medium.

ELECTRICS AND NON-ELECTRICS.—It was early discovered that all objects do not become electrified when rubbed. Glass, wax, sulphur, shellac, gutta-percha, etc., were found to be among those that did become electrified and were accordingly termed electrics, while iron, brass, copper, etc., did not and were accordingly termed non-electrics. This has been shown to be erroneous, for if iron, brass and other metals of the same kind are mounted on glass rods they can be electrified. The condition is simply due to the conductive or non-conductive properties of the metal. When a non-conductor is rubbed, electricity seems to adhere to its surface, but when a con-

ductor is excited, the electricity passes through it, and if it be connected with the earth by a conductor, such as the experimenter holding it in his hand without being insulated, it passes readily to the earth, and is neutralized. This, however, is impossible when the conductor is mounted on a glass handle and the operator does not touch it. This implies what is meant by the terms conductors and insulators or non-conductors. Conductors are those substances which allow electricity to flow along them, while insulators or non-conductors do not. Of the first class, the metals are all conductors with slight variations in their conducting properties, while glass, resin, wax, etc., are insulators.

SIMULTANEOUS AND EQUAL PRODUCTION OF BOTH ELECTRICAL STATES.—Neither positive nor negative electricity are produced separately; the presence of one implies that an equal amount of the other has been produced. One state appears on the thing rubbed and the other on the rubber; for instance, if glass is rubbed with silk, positive electricity appears on the glass and negative on the silk, and if resin is rubbed with flannel, negative appears on the resin and positive on the flannel. The fact that the two are equal is proved by imparting the electricity of the thing rubbed, and that of the rubber, to some insulated metal when it will be found that no electricity is present on the metal, for the equal charges have neutralized each other, thereby leaving it in its normal state.

ELECTRIC CHARGES AND THEIR DISTRIBUTION. —The quantity of electricity produced is known as an electric charge and may be of varying value. If an electric charge be produced on a non-conductor by friction, it remains just where the friction took place, not becoming distributed over it, or, if so, very slowly, but when a conductor is charged the electricity is immediately distributed over its entire surface, although not necessarily equally on all parts of it. A static charge of electricity always remains on the surface of the thing charged. It is easy to prove this in many ways; for example, the fact that it does not matter what the interior of the charged sphere

is, or whether there is any interior or not, demonstrates that the surface takes the entire charge. It should be remembered that this refers only to static charges, for dynamic currents flowing in circuits always flow through the substance of the conductor. The uniformity of distribution of an electric charge over the surface varies with the shape of, and the influence surrounding, the charged body. A sphere which is properly insulated and protected will have a uniform distribution of the charge over its surface. If a charged body be brought near the sphere, and is of the same electrical state as the sphere, as both being charged positively, it will repel the charge, or the greater part of it, to the opposite side of the sphere, while, if the approaching body be charged with the opposite state, as positive and negative, the charge, or the greater part of it, on the sphere will be drawn to the side nearest the approaching body.

If an elongated spherical conductor with rounded ends be charged, the greatest density of the charge will be found at the ends where the curvature of the surface is greatest. If the ends are made of different sizes (Fig. V) the greatest density

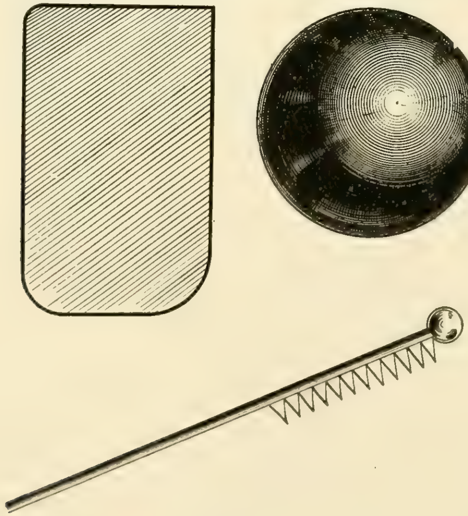


FIG. V.

will be found on the smaller, and if one end of the charged body is run off to a small point, the density will be so great that there will be a continual leakage of the charge at this point in the form of a spray. It is for this reason that in static treatments when we wish to give a continuous mild spray we use pointed electrodes, and for the same reason we use large round balls in the construction of the machine, and in fact at all places, as the rounded corners of the stool, etc., where we wish to prevent a leakage.

The charge on a flat, square surface has its greatest density near the corners and edges, but is evenly distributed over the flattened surface. If a conductor not charged be brought in

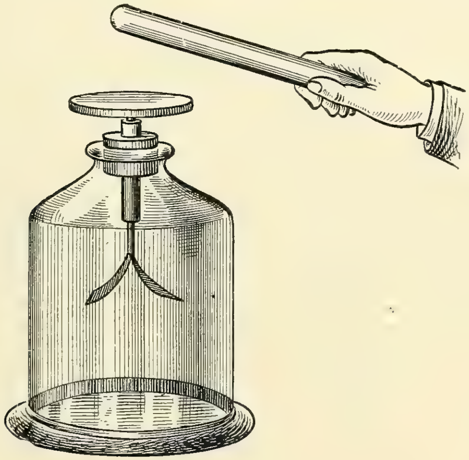


FIG. VI.

contact with a charged conductor, the charge will be distributed between the two in proportion to the capacity of the conductors; that is, if they are of equal size and shape the charge will be equally divided between them, but if of unequal size the larger one takes the larger charge. If a portion of a charge be removed from any part of a conductor, the remaining charge will distribute itself over the surface in the same proportion as before the part was removed, providing the same influence surrounding the charged body remains.

ELECTROSCOPE.—The instrument employed to detect the presence of a static charge is known as an electroscope (Fig. VI). It is of no material use in medical electricity, but owing to the frequent references made to it in electrical work, a slight description of it will be given here. It consists of two gold leaves suspended in a wide-mouth bottle by a copper wire or any other conducting material. We have seen that when bodies are in the same electrical state they repel each other; therefore when the upper part of the copper wire is charged with either a positive or negative charge the gold leaves are charged with the same and are accordingly repelled from each other.

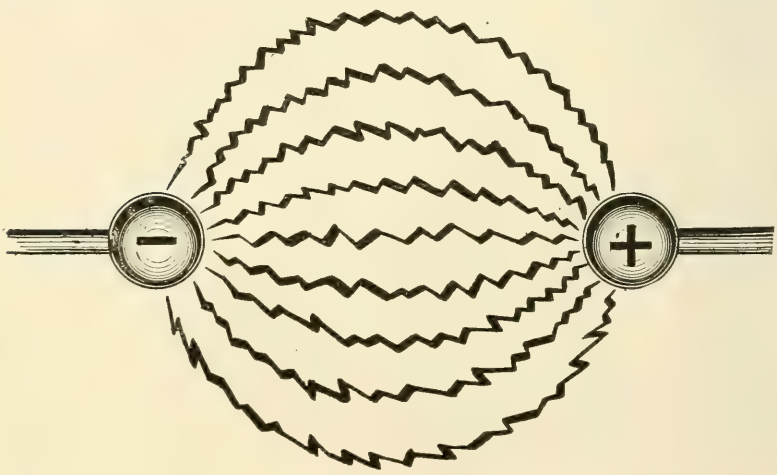


FIG. VII.

ELECTRICAL FIELD.—If oppositely charged bodies are brought near each other the space between them will be in a state of stress. The electricity on the bodies tends both to draw them together and also to draw the electricity on their surface together, which is the case when bodies are held stationary; in fact it is claimed that the bodies are only drawn towards each other by the attraction exerted by the charges for one another, which is probably true, but as a charge cannot

exist without having some body to rest on, the two propositions mean practically the same.

Figure VII represents two balls oppositely charged, as is the case on a static machine, and the lines running from one to the other represent the lines of electric force from the one charged at a higher potential to the one charged at a lower potential, or, otherwise, from the positive to the negative pole. These lines can be distinctly seen between the two poles of a static machine. It will be noticed all the lines do not run absolutely parallel, but tend to separate from one another in the middle. It is supposed there is a pressure midway be-

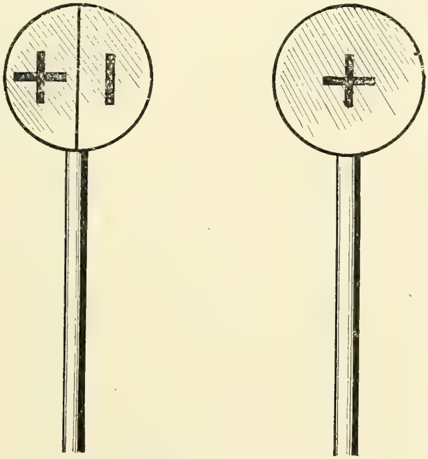


FIG. VIII.

tween the poles exerted at right angles to the lines, tending to widen them. It is also believed by some that this is partially accounted for, at least, by the fact that the charge is not evenly distributed over the surfaces, being most dense at the points where the balls nearest approach each other. The space included in these lines is known as the electric field, and it is in this field that we place the patient for treatment, but in that case we carry the field by means of conductors to some distance from the machine, as for instance to the insulated platform on which the patient sits.

INFLUENCE.—If a positively charged glass ball be brought near to, but not in contact with, an insulated conductor, as a large brass ball mounted on a glass pedestal, as in Figure VIII, the brass ball will exhibit all the characteristics of a charged body. If this brass ball is examined more closely, it will be discovered that an electric charge is on the surface nearest the glass ball, and also on the opposite surface, but that the middle exhibits no signs of electrification. If we now examine the glass ball, we find that it has lost none of its charge.

This power of a charged body to induce another charge in a body near it, but not in contact, is known as influence or electro-static induction. It was formerly termed induction, but that term is now used to indicate the induction of currents in coils—as the induced or faradic current—and the term influence is applied to the induction of static charges.

A closer examination of the brass ball will reveal the two charged surfaces in different electrical states; the side nearest the charged glass ball will be negatively charged (opposite to that on the glass ball) and the opposite side positively charged. As soon as the glass ball is removed the electrical charge on the brass ball immediately disappears. This is explained on Franklin's theory that all bodies contain electricity, and that when a glass ball, containing a positive charge is brought near the insulated brass ball it drives the positive or plus electricity to the opposite side leaving the near side negatively charged, and as soon as the charged glass ball is removed the two opposite electrical states rush together and neutralize each other. If a brass ball is not insulated, we find only the one kind of electricity, the negative, the positive being driven to the earth.

The quantity of the induced charge on the brass ball is in proportion to the amount of the charge on the glass—the greater the one the greater the other—and the nearness of their approach. A charged ball can never induce a greater charge than it possesses, that is, it can never produce a greater charge of negative electricity on its approaching side, and the same amount of positive on the opposite side. Bring the

charged glass close enough to the brass ball and the stress of the medium becomes so great that it breaks down, a spark passing from the positively charged glass ball to the negatively charged surface of the brass ball which is thereby neutralized, leaving the positive charge permanent on the brass ball, for when the influence of the charged ball is removed there is no negative electricity left to neutralize it as was the case before. If we wish to leave the brass ball permanently charged with negative electricity, the operator may touch it with his hand or with a wire connected with the earth, in fact, with anything that is not insulated, while it is yet under the influence of the glass ball, when the positive charge will escape to the earth, leaving the negative charge which will be permanent. The question naturally arises: Why does not the negative charge escape? The answer to this brings us to the definition of bound and unbound charges. The glass ball is charged with positive electricity; this has induced a negative charge on the near side and a positive charge on the opposite side of the brass ball. Now, it matters not what part of the brass ball is touched by the hand, the positive charge will escape, as it is "free" or unbound, but the negative, being "bound" by its attraction for the positively charged glass ball, does not escape. If the brass ball is now removed to a distance away from the glass, so that the influence of the latter is lost upon it, the negative charge being no longer bound to one side diffuses itself over the entire surface.

In the opening paragraph we saw how a charged glass rod attracted objects until contact was made and then repelled it; we are now able to explain that phenomenon. When the rod approached the swinging metal, the surface near it was negatively charged; consequently, an attraction is set up between the two opposite states; when, however, they come in contact the negative electricity of the metal is neutralized by joining with the positive charge of the glass rod, and we have two bodies charged with positive electricity which repel each other.

In order to charge the body by static induction or influence,

it is necessary that a non-conducting medium be between the charged body and the body to be charged, and the better this insulator the greater the influence of the charge, for if a sheet of glass be placed between the two, the influence of the charge will be greater on the body to be charged than if space alone is the only insulator.

ELECTROPHORUS.—(Fig. IX.)—The electrophorus was the first instrument invented to produce a succession of charges from one original charge. It consists of two parts, one a cake

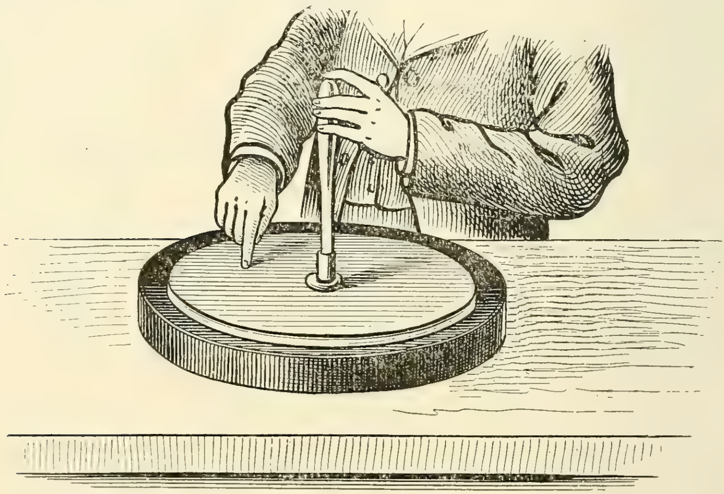


Fig. IX.

of some resinous material or sulphur, which is the exciting body, and a metal disk which is slightly smaller in diameter than the resinous cake, and is mounted on a glass or hard rubber shaft so that it can be handled by the operator without danger of losing its charge. The resinous cake is beaten or rubbed with a woolen cloth or catskin, when it becomes negatively charged. The metal disk held by the glass or hard rubber handle is placed down over it. Now, the charged disk of resin acts by influence on the metal plate, charging it with positive electricity on the lower and with negative electricity on the upper surface. Touch with the finger, and the free nega-

tive charge escapes to the earth leaving the positive charge on the lower surface, but this is diffused over the whole of the plate when it is raised by means of the glass or hard rubber handle. The knuckle is now presented to the plate, and a spark of the positive electricity will pass to it. This experiment may be repeated several times without diminishing the original charge of the resinous cake.

FRICTION MACHINES.—There are two general classes of electric machines producing static charges—one the friction, the other the influence machine. The former has been entirely superseded by the latter for medical use, but a description of a simply constructed friction machine will not be amiss, so that the distinction between the two may be more easily understood. Influence is a very important feature even in the friction machine and nowhere is it more simply illustrated. Fig. X is an illustration of one of the older and simpler forms

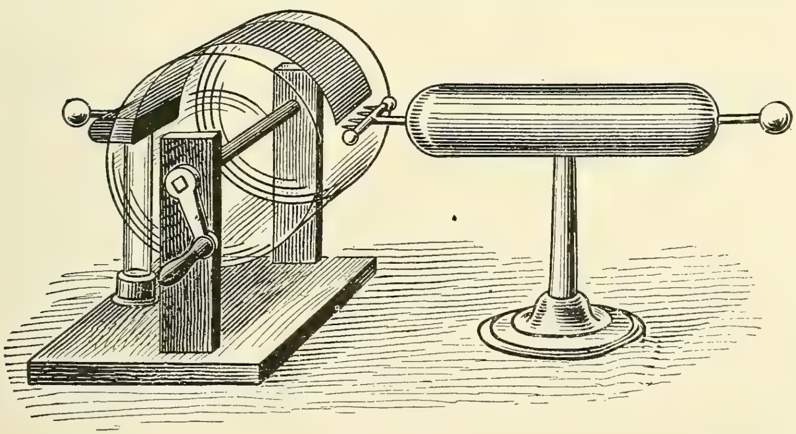


FIG. X.

of the friction machine. It consists of a glass cylinder so mounted on an axis that it can be turned by the hand. To the left is placed the rubber which is intended to produce the friction; this consists of a piece of wood mounted on a glass pedestal so as to insulate it. This piece of wood is covered on the side nearest the cylinder with a strip of leather, which has on its

surface an amalgam of zinc and tin. To this is attached a piece of silk which covers the upper surface of the cylinder. At the right is mounted on a glass pedestal for insulation an oblong brass cylinder with rounded ends, at one end of which is mounted a row of spikes known as collectors, and at the other the brass ball from which sparks may be drawn. This is known as the prime conductor. As the cylinder is made to revolve, the friction of the amalgamated rubber produces electricity, the positive adhering to the glass cylinder, and being carried over until it reaches the points; here it acts inductively, producing a negative charge on them and the near end of the brass cylinder, and repelling the positive charge to the other end or the ball. The effect of the points is to emit an electric wind between the points and the glass cylinder, thereby leaving the prime conductor charged positively, and, at the same time, neutralizing the positive charge on the glass cylinder so that it returns to the rubber in a neutral state. The negative charge of the rubber, which is equal to the positive charge of the cylinder, may be collected in a similar manner, or it may be conducted to the earth and neutralized. The plate machines, which are more commonly seen, act on precisely the same principle.

IFLUENCE MACHINES.—The development of the influence machine has revolutionized the use of static electricity in medicine. There are three forms on the market, known as the Toepler, the Wimshurst and the Holtz. Three principles govern the action of all these machines: First, there must be a slight initial charge. The Toepler and the Wimshurst are, however, self-exciting; the Holtz is not. Second, the principle of influence or static induction must be constantly borne in mind, and, third, what has been termed "the principle of reciprocal accumulation," in other words, the electric charge which is induced from an initial charge without taking any of it, is stored up in another body, which, in turn, induces other charges which are stored up in the first, and so on, each making the other stronger without giving up any of its own charge.

In order to make this more easily understood, as it is the

essential feature of these machines, let us glance at Fig. XI, which consists of two brass balls mounted on glass pedestals, and another suspended by means of a silk thread. Now, suppose the one to the right receives a small positive charge; the swinging ball comes near it, when the negative charge is induced on its approaching side and a positive charge is driven to the opposite side. If it is now touched by the finger the positive charge passes to the earth, leaving the ball negatively charged, which, when allowed to swing to the ball at the left, so as to touch, charges it with negative electricity; this in turn induces another charge in the swinging ball as it is

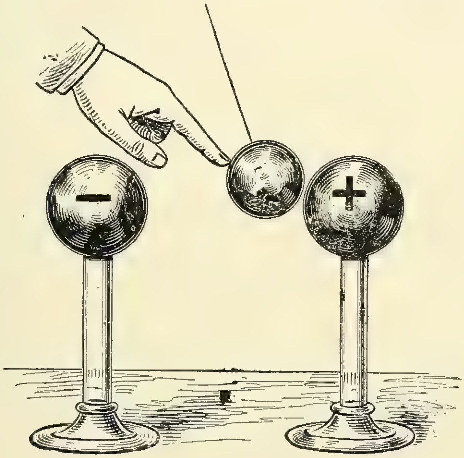


FIG. XI.

leaving, when if again touched, taking off the negative electricity and leaving the ball positively charged, it will, by touching the first ball, give it its charge, and another charge is induced in the swinging ball as it is leaving, and so on, accumulating charges after charges. This is the principle on which all different types of influence machines are constructed.

TOEPLER INFLUENCE MACHINE.—The Toepler machine consists of a stationary glass plate which has fastened to its outer side two strips of metal, known as its field plates, and

which are its inducing plates. A revolving glass plate has fastened to the side opposite the stationary plate smaller pieces of metal, known as the carriers; a pair of neutralizing brushes, a pair of appropriating brushes, and collectors or prime conductors, to collect and conduct the electricity generated to the poles of the battery.

Figure XII* represents the construction of a Toepler ma-

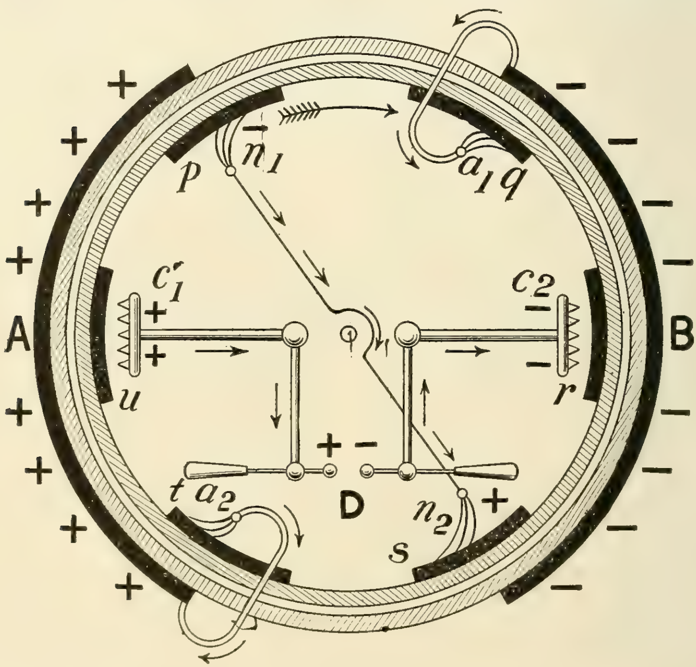


FIG. XII.

chine with two glass cylinders, which are used for convenience of illustration; the machines, however, are always made of glass plates. The outer glass cylinder is stationery and has attached on either side the field plates A and B. The inner cylinder revolves and has attached on its inner surface metal carriers P, Q, R, S, T and U. Running diagonally through

* Fig. XII is taken from Elementary Lessons in Electriciry and Magnetism by Sylvanus Thompsom.

the centre is a rod which has attached at either end the neutralizing brushes N^1 and N^2. The appropriating brushes A^1 and A^2 have metallic contact with the field plates. The collectors and prime conductors C^1 and C^2 collect and conduct the electricity to the poles at D. The operation of this machine is simple. Suppose there is a slight positive charge on field plate A. As the metal carrier passes along on the revolving inner plate it receives by influence a charge of negative electricity on the side nearest approaching the field plate, and a positive charge of equal quantity on the opposite. As it passes the neutralizing brush at N^1, the positive charge is conducted to S at N^2. As the inner plate continues to revolve P comes in contact with the appropriating brush at A^1, and,

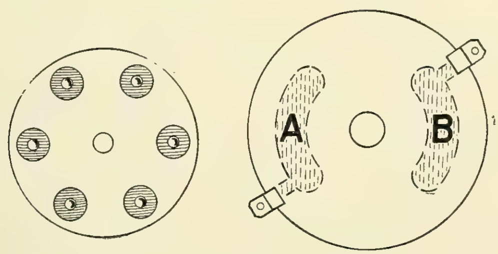


FIG XIII.

therefore, gives a negative charge to field plate B. As this carrier passes out from the influence of field plate B it is touched by the neutralizing brush N^2, leaving it positively charged; this charge it carries to field plate A at A^2, and so each receives a reciprocal charge from the other. When the carriers are touched by the appropriating brushes A^1 and A^2, they have, in proportion to their size, just as great a charge as the field plates. The carrier on the left, being positively charged as it approaches the collectors, induces two charges in it, which is the same as the prime conductor of the friction machine, the positive being repelled out to the pole while the points allow an electrical wind to pass across from the metal carrier, thus neutralizing the positive charge on it. It is then

charged again by influence. The field plate acts by influence on the prime conductor as well as does the metal carrier. Precisely the same process is taking place on the right side, except the charges are just the opposite.

Figures XIII and XIV represent a Toepler machine as it is seen in use to-day. It operates on precisely the same principles as the one just described, the only difference being that plates are used instead of cylinders. The two field plates, which are

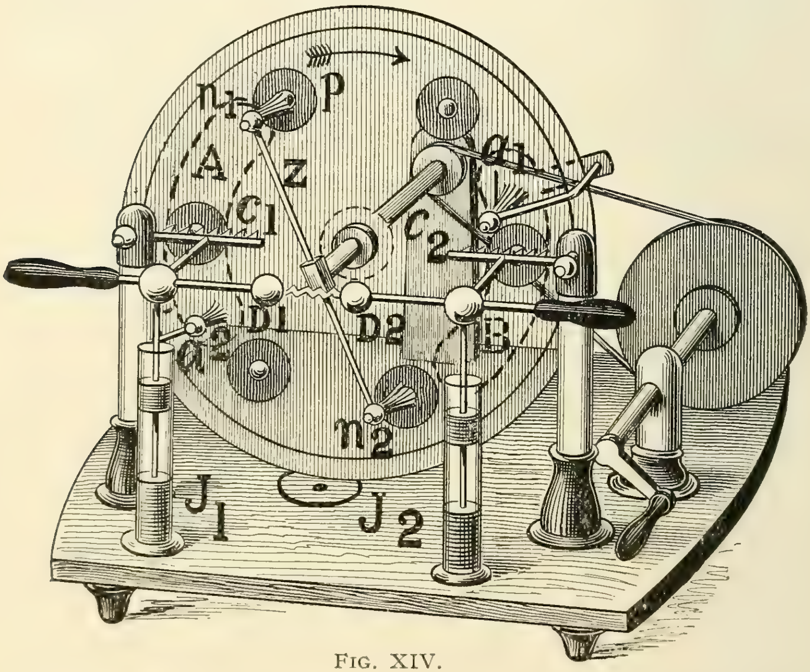


FIG. XIV.

made of paper and tinfoil, can be seen on the back of the stationary plate which is just behind the revolving plate, and is three inches larger in diameter. The metal carriers are distributed on the front of the revolving plate. They are round pieces of tin foil with a metal button in the center, and are securely cemented to the glass. The neutralizing brushes are attached to the bar, running diagonally across the front (Fig. XIV). The appropriating brushes have a metal connection

with the field plates by a strip projecting down from them to meet the arm of the brushes as they pierce the stationary plate outside the diameter of the revolving plate. The collectors or

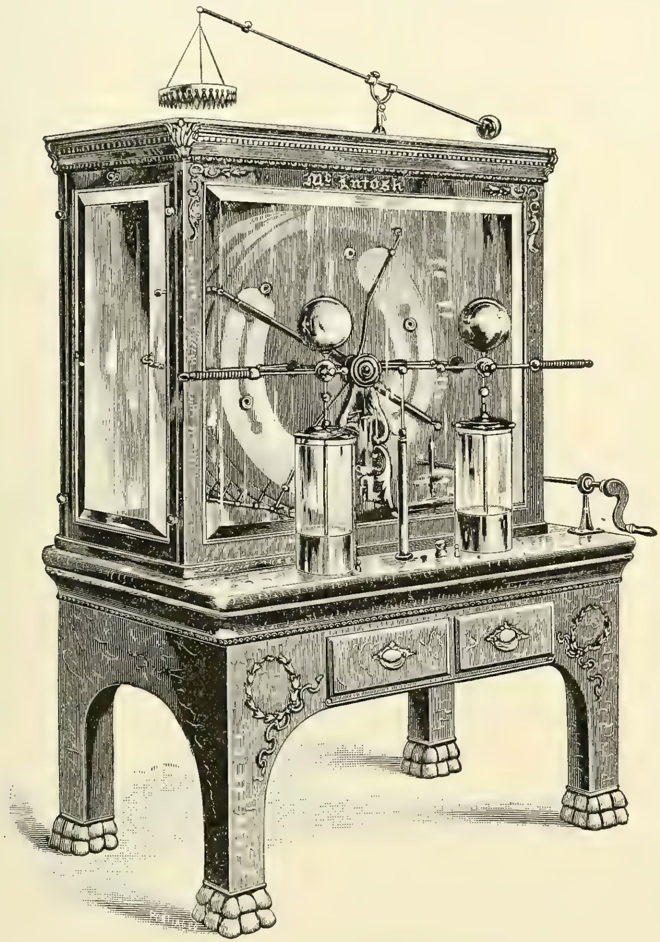


FIG. XV. Large Toepler Machine.

prime conductors have adjustable poles which can be drawn apart or closed at will. As seen in front, the Leyden jars are fixed, with their outside coating connected underneath the platform.

This machine is self-exciting and will generate electric charges in all kinds of weather, not requiring a case to protect it from atmospheric changes, although the use of that is advised to protect it from dust. It is simple in construction, requiring but little care. Both the neutralizing and appropriating brushes should make good contact with the metal carriers, and the neutralizing brushes should be so placed as to touch the carriers while under the influence of the field plates.

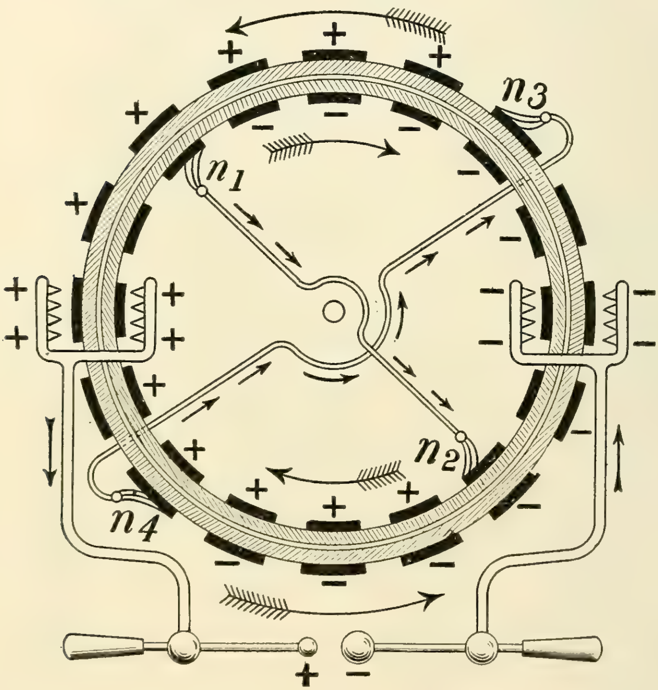


FIG. XVI.

WIMSHURST MACHINE.—The Wimshurst machine has no stationary plates nor has it any field plates. It consists of two glass plates which revolve in close proximity and in opposite direction, having on their outer surfaces metal carriers which act at the same time as field or inducing plates.

Figure XVI* represents a machine constructed from cylinders, one rotating inside, the other outside. The points of the arrows indicate the direction the cylinders are supposed to rotate. If one of the sectors at the top of the outer cylinder receives a slight positive charge as it passes along from right to left, it comes opposite a sector of the inner plate, which is being touched by the neutralizing brush N^1, and the positive or unbound charge is thereby conducted away; leaving the sector negatively charged. As this sector moves from left to right it comes opposite a sector on the outer plate, being touched by neutralizing brush N^3, which neutralizes its negative or unbound charge, thereby leaving it positively charged. After a few turns all the sectors in this way become charged, those of the outer plate on the upper half carrying positive charge from right to left, and those of the inner plate carrying negative charge from left to right. Exactly the same thing is going on at the lower half, with the exception that the respective charges are carried by opposite plates, the inner one carrying the positive and the outer carrying the negative charge. It will be seen, by a little study of the diagram, that the sectors of both outside and inside plates have the same charges, as they pass the collectors or prime conductors, those on the left having positive and those on the right negative charges. These collectors or prime conductors act the same as in the Toepler machine. Two charges are induced in them, the bound running on or off the combs, according to its positive or negative character, and neutralizing the charges on the sectors so that when they emerge from the prime conductor they are in a neutral state, ready for another charge of opposite potential to that they carried to the poles. Figure XVII illustrates the Wimshurst machine as it is seen in market. Let the front plate represent the inner cylinder of Figure XVI and the back plate the outer, and we have precisely the same action as we did in the cylinder machine.

---

* Fig. XVI is taken from Elementary Lessons in Electricity and Magnetism by Sylvanus Thompson.

One defect in the Wimshurst machine makes it inferior to the Toepler and the Holtz. If the sectors are placed close together the spark it is capable of producing is very short, and when the sectors are placed far apart the sparks are proportionately longer, but they are also proportionately less frequent. It is, therefore, impossible to get as large a volume of sparks of the same length as it is with the other machines. The use to which the Wimshurst machine is put is to charge the Holtz when only small machines are needed, and can be placed under the case or inside of it. These small Wimshurst's

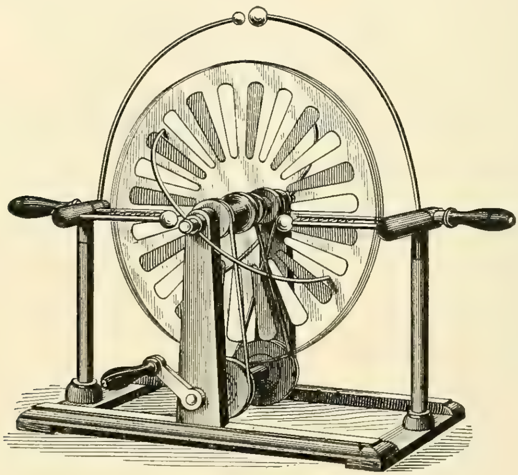


FIG. XVII.

have been recommended as portable static batteries, but as such they are of little use. If a Wimshurst machine is in order it will generate electricity in any weather. Care should be exercised in using the Wimshurst to see that the brushes make good contact, that the neutralizing brushes slope in different directions, and that the sectors come opposite each other when they are touched by the neutralizing brushes.

HOLTZ INFLUENCE MACHINE.—The Holtz influence machine differs mostly from the other two by not having metal carriers on its rotating plates and no distinct neutralizing

brushes, consequently it is not self-exciting. Figure XVIII represents a Holtz machine made of cylinders. It consists of two cylinders, the outer one fixed, the inner one rotating in the direction of the arrows. The field plates on the outer side of the stationary cylinder marked *A* and *B* have pointed tongues which dip through openings in the outer plates, coming in close proximity but not in contact with the inner or revolving plate. The collectors or prime conductors *C* and *D* are seen in the center.

The working of this machine is easily understood, providing one has followed the laws of static induction or influence as they have been traced from the beginning. Suppose that field

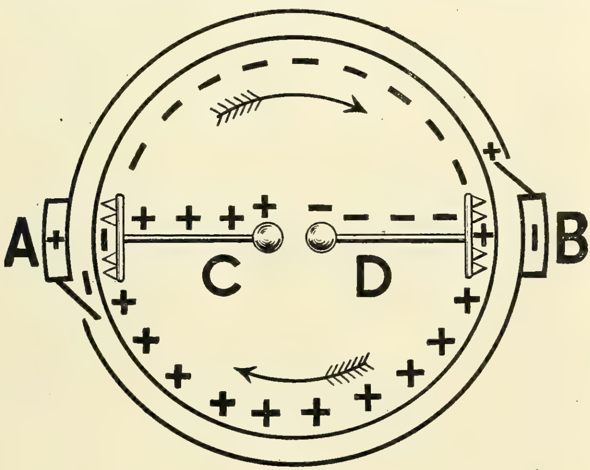


FIG. XVIII.

plate *A* has received a positive charge, it at once induces a charge on the prime conductor inside the revolving plate; the positive charge is repelled inward to the pole, and the negative attracted back to the revolving glass plate, and as the teeth of the combs are pointed a spray of electricity passes between them and the rotating plate, leaving its inner surface negatively charged. If this plate be now turned, this negative charge is carried over to the opposite side, where it induces a charge on the prime conductor of the opposite side. Here

the negative charge is repelled inward to the pole, and the positive charge is discharged from the points neutralizing the negative electricity, and at the same time recharging the surface of the plate positively, which, when carried around to the other side, augments the charge which has already been established on that side. The pointed tongue of paper on the outside connected with the field plate always lets off electric

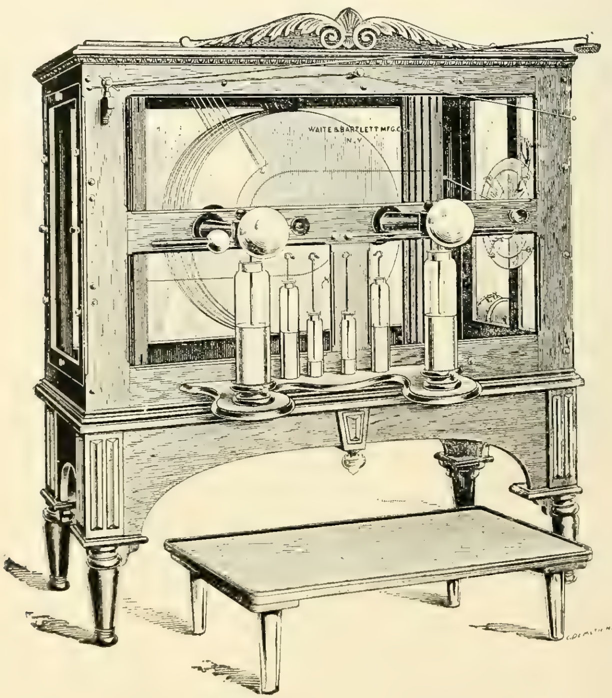


Fig. XIX. Large Holtz Machine.

winds when the front plate is revolved in the opposite direction to the point, which is opposite to that which is coming toward it on the revolving plate and is simply the unbound charge constantly being induced in the field plate. For instance, if in Figure XVIII a positive charge is carried under from right to left, the tongue at *A* will let off a negative charge, thereby leaving the field plate more positively charged, which in turn induces

a strong charge on the prime conductor opposite. In this way charges are built up in the field plates, and enormous quantities are collected and thrown off at the poles. The Holtz machine is very sensitive to atmospheric changes; one should have it put in as near a hermetically sealed case as can be made. All static machines are more or less influenced by the weather, and should, therefore, be kept in a dry, sunny room if possible.

The Toepler and the Holtz are the only practical working machines in the market; our experience has been confined entirely to the Holtz, with which we are perfectly satisfied, but we are acquainted with many physicians who speak in the

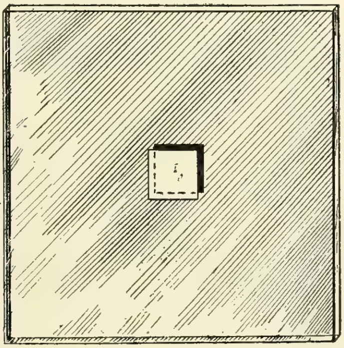


FIG. XX.

same way of the Toepler. A static machine should be selected which is capable of throwing voluminous sparks from seven to ten inches in length at least, in quick succession, across from pole to pole, when the outside of the Leyden jars are connected. The small machines with plates from fifteen to twenty inches in diameter are good for nothing, and we have never seen one too large for use.

LEYDEN JARS.—If a pane of glass be set up edgewise and a piece of tinfoil cemented on the middle of one surface of it, thus perfectly insulating it, the charge which it is capable of taking will be very small. Place now another piece of tinfoil on the opposite side of the glass (Fig. XX), and the

capacity of the first for holding a charge will be somewhat greater. The reason for this is, that there is by influence a charge created on the second piece of tinfoil, which attracts the charge of the first to the side of the glass, leaving space for a heavier charge. Suppose a positive charge is given to the first piece of tinfoil, the charge next the glass in the second piece will be negative and that on the outer side positive. If now we connect the second piece of tinfoil with the earth by means of a wire, or the hand of the operator, and conduct off the positive charge, thereby leaving greater space for the negative it is possible to get a much greater charge on the first. By this means we are able to store up a very considerable charge. If several panes of glass, or one very thick piece, is used, the charge will not be so great as when one thin piece is used, as the attraction would be less. Poor glass, which is not so good an insulator as that of a good quality, as the impurities conduct more or less, does not retain so high a charge.

This is the principle of the Leyden jar. The inside of the jar is coated with tinfoil as well as the outside. The rod running from the machine, is connected with the inside coating by means of a brass chain. It should be understood that the coatings of tinfoil do not contain the charge which in reality remains on the surface of the glass, for if they are removed they contain scarcely any electricity, but on returning them to their position, the charge is the same as before they were removed. If one Leyden jar is to be charged, it is necessary to connect the outside coating with the earth, so that the free, unbound electricity may escape to make room for the bound charge. When, however, two jars are to be charged, as on an electric machine, the two outside coatings are connected. As the positive pole leads into one there is a free or unbound positive charge on its outside, and as the negative leads into the other, there is a free or unbound negative charge on its outside. Connecting these two unbound charges, positive on the one and negative on the other, by means of a rod they rush together and, consequently, neutralize each other, the

same as if both were connected with the earth. The connection of the outside coatings of the jars is done by laying a small brass rod across hooks provided for that purpose on the Holtz machine.

As the Leyden jars store up electric energy, positive on one side and negative on the other, it is plain that in order to discharge one, the outside and inside must be connected by some conducting material, or at least brought close enough together so that a spark may pass. The larger the jar, the greater the charge it will contain. The office of the Leyden jar, when attached to an influence machine, is to store up a quantity of electricity and let it off in large volumes. If a static machine is set in motion without the attachment of the Leyden jars, or even with them attached but their outside coatings not connected, a luminous spray will pass from one pole to the other so long as the two discharging poles are near together but do not touch. As these discharging poles are drawn apart the spray changes color, is not so luminous and is more interrupted. Now, connect the two outside coatings and large, powerful sparks will jump across. The Leyden jar simply collects the electricity until it can contain it no longer, when the two charges rush together. The rapidity of the discharge will depend on the greatness of the charge and the capacity of the machine. When the jars are used during stactic treatment, and their outside coatings connected, they simply increase the size and volume of the spark. They are, also, used in what is known as static induced treatment, which is the alternating current but having a greater velocity in one direction similar to the faradic current but of course differing from the faradic in character of discharge. While the jars are filling, the unbound charge is passing through the patient connected with the jars with but feeble intensity, the Leyden jars become filled until they can contain no more, when suddenly a spark passes between the two poles of the machine; this spark suddenly empties the Leyden jars, the bound charges on the outside of the jars are as suddenly released and rush through the patient with enormous intensity and in just the oppisite direc-

tion to the unbound charge. While these two are equal in amount, the electro-motive force of the bound charge is so much greater than the other that it predominates just the same as the make current with the Ruhmkorff coil. When the plates of the machine are made to revolve rapidly, the force of the charge is so great that the Leyden jars are filled and emptied many times per minute.

To have a static machine give the best results it requires care. As dust acts as a conductor of such high potential currents the case and prime conductors should be thoroughly wiped with a warm dry flannel. During warm, humid weather the case must be kept dry by placing inside of it dishes containing chloride of calcium and having it as nearly hermetically sealed as possible. When the calcium becomes saturated with moisture it should be replaced.

In testing the polarity of a static machine the poles should be drawn a few inches apart, when a bright spark will appear at the cathode. This test is only reliable when the poles are separated but a few inches (three or four) and is not to be altogether depended on when they are drawn wide apart.

DYNAMO STATIC MACHINE.—Prof. Elihu Thompson read a paper before the New York Electrical Society in 1899, describing a machine capable of giving off very high potential charges; this he called a dynamo static machine. The machine is perhaps best described in Prof. Thompson's own words given in the Catalogue of the *Conversazione* of the American Institute of Electrical Engineers held at Columbia University, April 12th, 1901, and which is as follows:

"This machine contains a small direct current motor, the windings of which are tapped and connected to two rings giving a primary alternating current for the operation of a step-up transformer which gives a secondary current of about 20,000 volts, being capable, however, of regulation through a wide range. The tops of the alternating current waves of high potential obtained from this secondary transformer are used to charge a number of glass plate condensers in parallel. The rotating frame synchronously driven with the motor

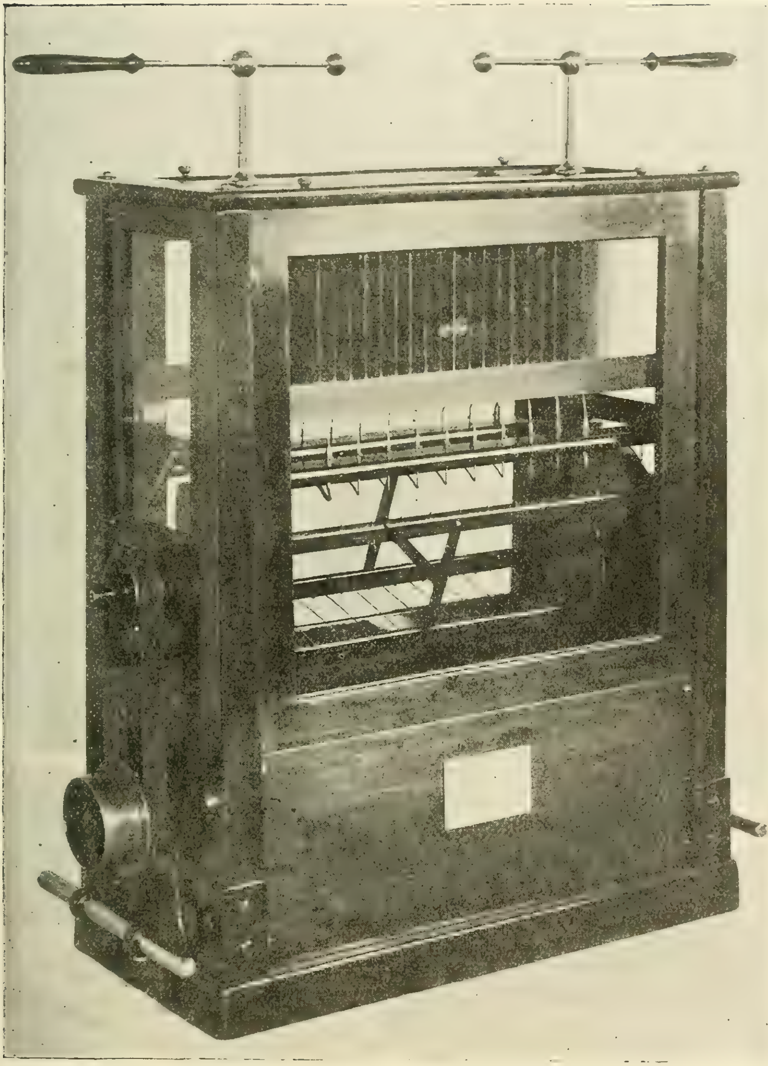


FIG. XXI. Dynamo-Static Machine.

makes the connection to the condensers periodically and in synchronism with the alternating current. The connection by the rotating frame is alternately in parallel and in series, condenser plates being charged to 15,000 volts and with 10 in parallel, giving 150,000 volts when connected in series. The machine therefore furnishes from low pressure direct current, high potential discharges of definite polarity at the discharged terminals."

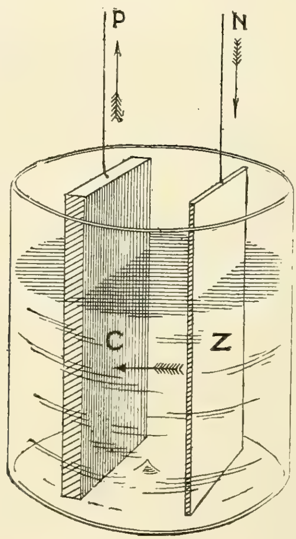


FIG. XXII.

It would appear from this that the discharges are entirely from condensers. If this is true it is a question if the machine can ever be utilized for static work. If it can be used it certainly possesses some advantages as it is small and compact, and is but slightly affected by the weather, but so varied are the physiological effects of electric currents and charges that we cannot always be guided from the physicists standpoint, and the dynamo static machine must first prove itself equal to the static machine before it can be recommended.

Dynamic Electricity or Electricity in Motion.—Under this head we may properly consider the phenomena of the electric current

produced by chemical decomposition, by a dynamo or by induction, be it either a continuous, alternating or interrupted flow of current.

When a plate of zinc and a plate of copper or carbon are partially immersed in a vessel containing dilute sulphuric acid, without touching each other, as in Fig. XXII, a slight disengagement of hydrogen gas results. This is set free at the zinc plate. If the two plates are connected by means of a metal wire, as in Fig. XXIII, a larger quantity of hydrogen is set free, but now at the copper plate instead of the zinc. This new action which takes place on account of the two metals being

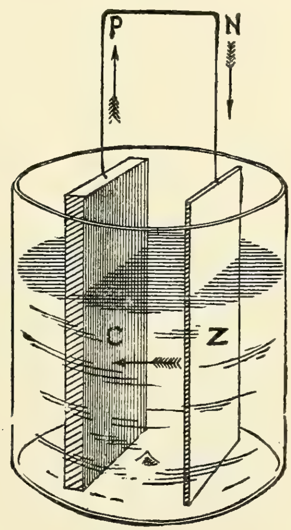


Fig. XXIII.

connected, namely, the increase in the amount of gas given off and its being given off from the copper instead of the zinc plate, is not to be explained by chemical action alone. If we examine the wire connecting the copper and zinc plates, we find it possesses several remarkable properties. We will consider but two of these properties, those that are known as the thermal and inductive properties.

First: If the bulb of a sensitive thermometer is placed against the wire, the rise of the column of mercury will indicate the presence of heat and determine the thermal property.

Second: If a wire connected with the two poles of a sensitive galvanometer be brought close and parallel to the wire connecting the zinc and copper, a deflection of the needle will be produced. This we may term the inductive property. When a wire exhibits these phenomena, an electric current is said to flow or be flowing through it.

We must, however, distinguish between a current of electricity passing along a wire, and a current of water flowing through a pipe, for, in the latter case, the water is distinct from its conductor, while with the former it is not, but is simply a changed state of the conductor itself. Without going into any of the discussions regarding the nature of the electrical current, we shall simply state that its direction is from the positive along the conductor to the negative pole. The force, by virtue of which this current flow is produced, is called the electro-motive force.

The arrangement of two metals, Fig. XXIII, is called a voltaic couplet, or commonly a primary cell, and several of these cells constitute what is known as a galvanic battery. The current produced by this battery has various names, such as the battery current, the constant current, voltaism, and galvanism, but is generally known in electro-therapeutics as the galvanic or continuous current. The conditions under which a current of electricity is created in the above cell may be illustrated by reference to the conditions which exist in and cause a flow of water between two reservoirs when one is on a higher level than the other. If they are connected by a pipe, the water will flow from the higher reservoir to the lower until the level is the same in each. If, however, the lower reservoir is so large as not to have its level affected by this flow from the upper, and we have a means of keeping the upper reservoir full, then we shall have a continuous flow from the upper to the lower reservoir. The same is true with electricty.

There has been much confusion of the terms difference of

potential and electro-motive force; practically the two are the same and yet they are quite different in certain ways that they may be used. We have seen that it was necessary to have two dissimilar materials immersed in a corrosive liquid, to produce an electrical current. This is because the action of the liquid must be greater on one than on the other. If a plate of platinum and another of gold were immersed in pure nitric acid no current would be produced as there is no action on either, but with the addition of a few drops of chromic acid, the solution attacks the gold but not the platinum, and a current is generated, its direction being from the gold to the platinum. Now the greater the difference with which these two elements are acted upon by the solution, the greater the difference in potential. The one most acted upon is known as the higher potential and the one least acted upon as the lower potential. As zinc is the most acted upon and carbon the least acted upon by the solutions generally used, of any of the cheaper materials, making the difference of potential greatest, is the sole reason for selecting these for the elements in the construction of a battery.

That this may be made more plain, let us return to the reservoirs. One reservoir is placed above the other and a current of water flows from one to the other by means of a connecting pipe. In this case, the higher reservoir corresponds to the element of the highest potential, or the one most acted upon, and the lower, to the lower potential, or the one least acted upon, the difference in the height corresponding to the difference of potential in a cell, the rate of the flow of water corresponding to the electro-motive force, or the force which supposedly leaves the zinc to go through the liquid to the copper plate, but which in reality is due to the stress set up between the two elements. It is easily to be seen, the higher one reservoir is above the other, the greater will be the force of the current of water, and the greater the difference in potential of the elements, the greater the electro-motive force.

We have been dealing with the rate of current flow and not the quantity. If we were to substitute for the small pipe

which connects the upper with the lower reservoir, a large one, the quantity of water which would flow through it would be greater because the resistance of the large pipe would be less than the smaller one. The same rule holds good in electricity, a large wire offers less resistance to the passage of a current of electricity than a small one, and a large surface has less resistance than a small one; therefore, when we have very large plates in a battery exposing a large surface of fluid as a conductor, we decrease the resistance and consequently increase the quantity, but not necessarily the rate of current flow, any more than we would increase the rate of current flow of the water by using the large pipe to connect the reservoirs, although we certainly increase the quantity of water which is passed.

As we have seen, the current flow is supposedly from the most corroded higher potential zinc plate through the solution of the cell to the less corroded lower potential carbon plate. Bearing in mind the fact that the current always flows from the positive to the negative, we trace it from its starting point at the surface of the zinc plate through the solution to the carbon plate which conducts it up to the connecting wire, which in turn conducts it back to the zinc plate; therefore, below the surface of the solution the zinc is positive, as the current travels from it, and the carbon is negative, as the current is conveyed toward it, while above the solution in the cell the carbon is positive, as the current travels from it, and the zinc is negative as the current is conveyed toward it. This explains why the positive pole of the battery is attached to the negative element or plate.

OHM'S LAW.—It now becomes necessary to demonstrate what is known as Ohm's Law, but in order to obtain a knowledge of the principles of that law we must first understand the units of electrical measurement. We let E stand for electromotive force, which it will be remembered is the initial force of the current and is measured in volts. R stands for resistance which is measured in ohms and is the opposition offered to the passage of the current and may be divided into internal and

external, the internal being whatever intervenes between the plates inside the cell, such as the liquid or porous cup, if one be used, and the external resistance being whatever intervenes between the poles outside the cell, being the conducting wire, and in the medicinal use of electricity that part of the body in the circuit. C stands for current strength or the current that actually passes through the conductor and is measured in amperes, though in the medicinal use of electricity we divide it by one thousand and use the milliampere.

Ohm's law is then expressed by the formula, $C = \frac{E}{R}$, viz., $\frac{\text{The electro-motive force}}{\text{The resistance}}$ = the rate of the current flow. It will be seen that, if two of these factors are known the other may be readily obtained, for if $\frac{E}{R} = C$, and we have E and R known, we readily obtain C.

If C and R are known, then $R \times C = E$, and finally, if C and E are known, $\frac{E}{C} = R$; letting $E = 4$, $R = 2$, then $4 \div 2 = C = 2$. Second, $C = 2$ and $R = 2$, then $2 \times 2 = E = 4$; and, third, $E = 4$ and $C = 2$, then $4 \div 2 = R = 2$. This law may be expressed by the following formula: $C = E \div R$, $R = E \div C$, $E = C \times R$.

WEAKENING OF CURRENTS.—The weakening of a current may be due to the development of resistance in the circuit, such as the corroding of the connections, partial destruction of the conductors, or anything which interferes with the free flow of the current. The chief causes of weakening the electro-motive force of a battery are polarization and local action.

POLARIZATION.—If the wire connecting the positive and the negative pole be one offering little resistance to the passage of the current, after a short time the strength of the current will greatly diminish, and finally cease altogether, or nearly so. If now we examine the copper plate carefully we shall find it covered with minute bubbles of hydrogen, which form an intervening layer between it and the solution of the cell; so we have a plate of hydrogen, practically, instead of a plate of copper and the current is weakened.

The hydrogen collected on the copper plate also tends to

react upon the sulphate of zinc formed by the dissolving of the zinc in the solution, when sulphuric acid is used, and to cause a deposit of zinc upon the copper, thus still further diminishing the electro-motive force of the couplet—instead of having a plate of copper and another of zinc, we in reality have two zinc plates. The weakening of the current from all of the above causes is termed polarization. To restore a cell to its original power, the solution may be agitated by moving the elements in the fluid, thus washing off the bubbles of hydrogen, or by blowing air in between the plates. Cautery batteries, which polarize rapidly, are so constructed that the plates can be moved in the fluid or provided with means for blowing air to agitate the fluid in them. Breaking the circuit and allowing the battery to rest for a moment will also cause the hydrogen to escape. Roughening the surface of the negative element in some types of batteries will cause the bubbles of hydrogen to escape. We will also discover, when we come to discuss the different cells, that various methods, both chemical and mechanical, are employed to prevent polarization.

LOCAL CURRENTS.—If the zinc is not chemically pure, the impurities set up local currents, caused by particles contained in it that are electro-negative to the zinc, forming minute closed circuits, thus destroying or diminishing the effect of the plate as a whole with the negative plate. This local chemical action caused by the impurities may be overcome by thoroughly amalgamating the zinc plate, by immersing it in a vessel containing metallic mercury and dilute sulphuric acid, and then rubbing it with a swab, which gives it a fine, even coating of mercury so that it acquires all the properties of chemically pure zinc. With some cells the addition of the bisulphate of mercury to the solution will keep the zincs amalgamated.

SECONDARY CELL—STORAGE CELL—ACCUMULATOR.—The name storage cell is more commonly known to the medical profession, but as it will be seen, there is no such thing as storing up electricity, at least storing it up in a cell known as a storage cell, it is evident that the name secondary cell or accumulator is better.

The one place where electricity is actually stored is in a Leyden jar.

When a current of electricity is passed through a secondary cell, it produces certain physical and chemical changes in the plates, which, in turn, produce a current running in the opposite direction. When these plates return to their normal condition, electricity ceases to be produced.

There are still some makes of the old lead plate, each maker having different methods of rendering the plates porous, which is the chief aim in the improvements in the lead plate type. Some build them up with lead ribbon; others cast them porous; but a majority of the manufacturers of this type treat the plates with nitric acid after they are cast. All, however, are striving for the one object, porosity.

These plates are put into a vessel containing a sulphuric acid bath, and so arranged that every other plate is positive and the others negative; that is, every alternate plate is connected by means of a strip of lead with the positive pole of the charging apparatus, and the others to the negative. The plates are separated from each other by some non-conducting material, such as perforated corrugated vulcanite sheets, hard rubber pin insulators, etc., and the whole held firmly together by mechanical means. Although the plates are identical when placed in the vessel or bath of nitrate for the forming process, after a current from a primary battery or dynamo has passed through them, their chemical composition is changed by forming, that is, building with active material (lead peroxide). The plates, after being formed, are thoroughly washed. They are then placed in a dilute sulphuric acid bath and formed as negative, all remaining impurities being removed. The plates are again washed, and those for positive plates are reformed in a dilute sulphuric acid bath after which they are ready to adjust for a completed battery.

Upon charging there is rather a thick layer of spongy lead on the plate connected with the positive, and oxide of lead on the one connected with the negative pole. When the battery is discharged the direction of the current is reversed, conse-

quently the oxide plate becomes positive and the spongy plate negative. While discharging, the positive plate has its oxide reduced to a lower form, some of it being reduced to spongy lead, while the negative plate is partially oxidized. Thus, in the process of charging and discharging there is an alternate change from metallic lead to oxide of lead, and from oxide of lead to metallic lead.

The chloride and other pasted plates are made in different ways, but in all the object is to produce a proper support of lead and antimony and pastes of a hard and durable character.

The composition used for these grids or supports is an alloy of lead and antimony, the alloy being far stronger than the lead alone and practically unacted upon by the electrolyte. These plates are made porous so as to receive the paste; some makers cast them with salt, the dissolving of the salt leaving them porous. Others drill holes in them and then hammer them leaving the opening narrower on the surface than in the centre; so when the pastille forms are placed in them they cannot get out. There are some makers who have recently cast the grids around the pastilles. The plates intended for the positive are pasted or filled with a mixture of red lead and sulphuric acid and those intended for the negative plates with litharge and sulphuric acid. The pastilles for the chloride plates are usually made by fusing lead chloride, with zinc chloride, and when in the molten state casting it into moulds forming pastilles. These are placed into the supporting grid, between zinc plates in a solution of zinc chloride, and short-circuited for the purpose of removing the chloride. In building up a section of the plates in a cell, the number of negative plates always exceeds the positive by one, so that the negative is seen on each end.

One of the most common accidents to storage cells is what is known as buckling of the plates, which is a twisting of them, thus leaving a crooked surface instead of a straight one, frequently close-circuiting the cell internally and thus depleting the energy. This is caused by either charging or discharging the battery too rapidly. Another result of charging

too rapidly is known as sulphating, which is the deposit of a film of lead, a bad conductor, over the surface of the plates and is manifested by the plates turning white.

The rate of charging should never exceed the rate of discharging. The average which has been found best by one of our large New York firms, is to pass about fifteen volts through

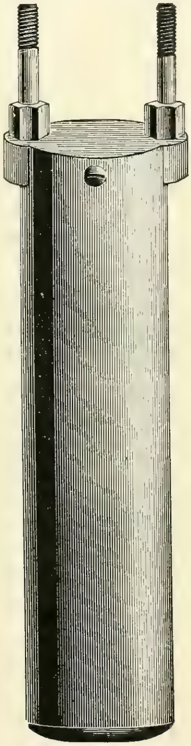


FIG. XXIV. Chloride of Silver Cell.

plates six inches square, and increase or decrease the number of volts in proportion to the size of the plates.

DESCRIPTION OF PRIMARY CELLS.—There are many different primary cells but attention will be called to only three forms.

The bichromate cell is frequently used for portable batter-

ies. It has disadvantages, such as the fluid weakening, and spilling and corroding the metal parts of the battery, and it requires constant attention to keep it in order; but it is very useful when a strong current is needed for a short time as in the medicinal use of electricity. There is no portable battery equal to it to produce very strong currents, such as are often used in electro-gynæcology and electro-surgery. It is composed of zinc and carbon elements. The fluid is made of water, sulphuric acid and bichromate of soda, as less crystalline deposit forms than with potash which was formerly used.

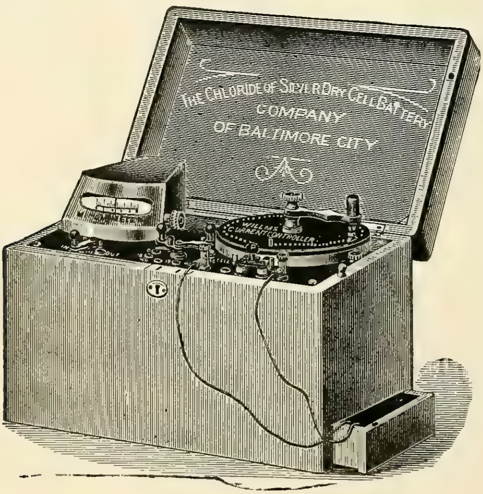


FIG. XXV. Chloride of Silver Battery.

The chloride of silver cell has lately come into use for medical purposes. A chloride of silver battery is very portable, being light, compact, clean and easily kept in order. It is also quite constant, if the external resistance is sufficiently high, and it has a sufficient electro-motive force for all ordinary medical work. The exact construction of chloride of silver cells on the market is more or less of a secret, but the principle is the same in all. The elements are zinc and chloride of silver; the chloride of silver may be inclosed in a hollow, cylindrical diaphragm to which is fused a silver wire leading

up out of the cell. The fluid used is a weak solution of sal ammoniac.

The Le Clanche cell has taken the place of all the other forms for stationary batteries for medical use, and it is one of the most useful of cells for galvanic work. There are various forms of these cells, but the one most commonly used is composed of a rod of zinc and a porous earthen cup filled with binoxide of manganese and carbon. The solution is sal ammoniac. If this cell is used in a continuous circuit for any considerable time, the current weakens from polarization, hydrogen collecting around the carbon, but if the circuit is broken at short intervals the binoxide of manganese yields up

Fig. XXVI. Le Clanche Cell.

some of its oxygen which removes the hydrogen by joining with it to form water. This is, according to our experience, the best cell in the market for cabinet batteries.

THE CONNECTING UP OF CELLS TO FORM A BATTERY.—If two or more cells are connected so that the negative of one is joined to the positive of the other, as in Fig. XXVII, they are said to be connected in series, or the term tension is sometimes used. When cells are joined in this way, with every addition of a cell there is a corresponding addition of its electro-motive force. For instance, if the electro-motive force of the cell is two volts, when two cells are connected in this

way we have four volts, three cells six volts, and so on; but if we connect the cells so that the negative of one is joined to the negative of the other, and the positives united as one as in Fig. XXVIII, we would not get such results. No matter how many

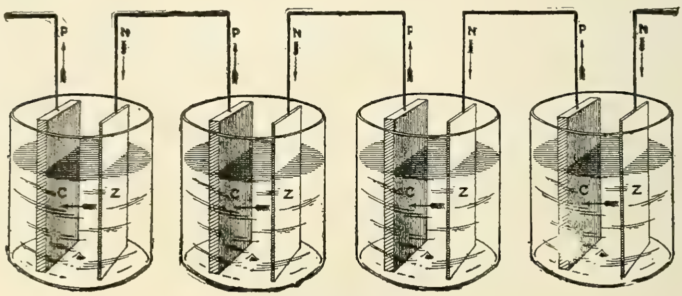


FIG. XXVII.

cells are added we only get the number of volts that is in one, for, instead of adding the additional electro-motive force of the other cells we simply increase the size of one cell the same as if we were increasing the size of the plates of one cell, in the same proportion as those of the additional cells. This increases

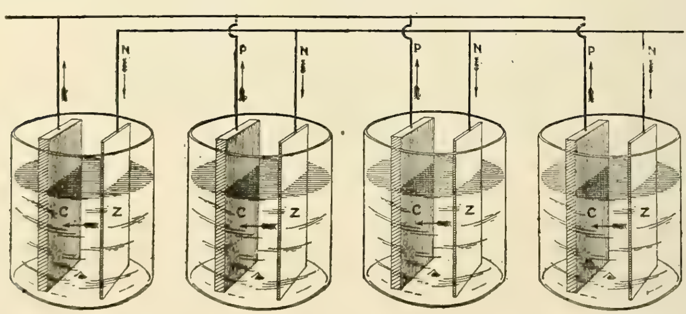


FIG. XXVIII.

the quantity the same as using a large pipe between the reservoirs, but does not increase the rate of current flow, and consequently does not increase its power to overcome resistance. Cells joined in this way are said to be connected in multiple or for quantity. In the medicinal use of electricity, where the resistance to be overcome is great, we connect the cells in

series for intensity, but for cautery purposes, when there is but little resistance in the circuit, and when a large quantity is needed to produce the heat, we connect them in multiple or multiple series for quantity.

ACCESSORIES TO A GALVANIC BATTERY.—RHEOSTAT.—A rheostat is an instrument by which a varying or required amount of resistance may be thrown into the circuit.

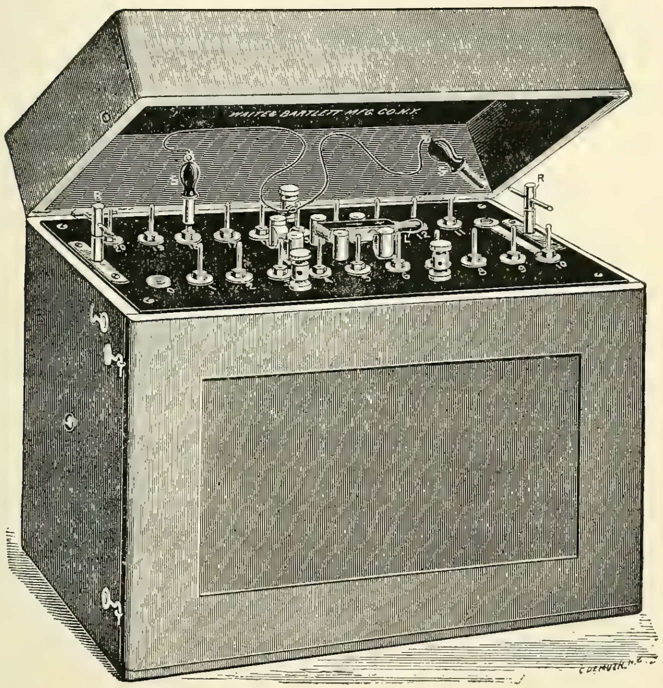


FIG. XXIX. Portible Galvanic Battery.

Ohm's law taught us that the current strength is inversely to the resistance in the circuit, therefore, when we use a rheostat in the circuit we simply employ an instrument with which we can place as much or as little resistance in the circuit as is needed to give us the required strength. The object of this is

to be able to increase or decrease the current strength with a smoothness that cannot be attained by adding or diminishing the number of cells. If the rheostat is a good one and handled nicely, the current is increased or decreased with great smoothness.

There are three general types of rheostats, the water rheostat, the graphite rheostat, and the wire rheostat. The first is based on the principle that water forms a great resistance. By inserting in the circuit a column of water with a mechanical arrangement for decreasing or increasing the length of this column, thus decreasing or increasing the resistance at will, we have a very efficient rheostat.

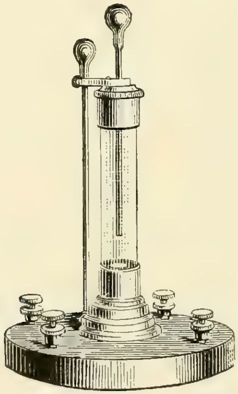


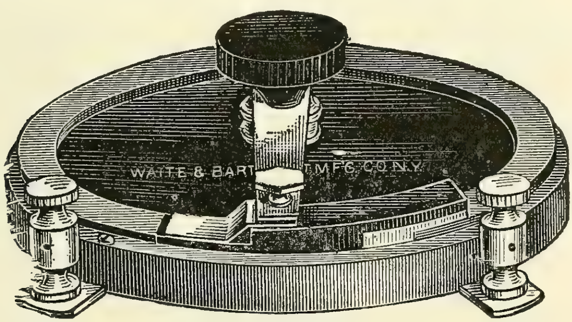
FIG. XXX. Water Rheostat.

The graphite rheostat was first employed in electro-therapeutics by Dr. John Butler, who was indebted to a suggestion of Mr. Thomas A. Edison for the idea which led him to its use. This same instrument in different shapes has recently appeared over various supposed inventors' names. It consists of a piece of porcelain on which graphite is thinly and evenly spread. This graphite, not being the best of a conductor, furnishes sufficient resistance. As the arm carrying the contact springs is turned around from the starting point, there is less and less of the thin film of graphite for the current to traverse and consequently less resistance. This is an excellent rheo-

stat when in good order and when the film of graphite is evenly spread over the surface.

Wire rheostats are usually made of German silver wire wound on spools, but are not frequently used in electro-therapeutics, except for controlling the electric light currents, which will be given later.

MILLIAMPERE METER.—For many years galvanometers having different values were used in electro-therapeutics, but as these instruments did not represent any specific strength of current, no two could be compared, as the number of degrees registered by one had no relative value with another. We are



XXXI. Graphite Rheostat.

indebted to De Watteville for the present milliampere meter, but to Gaiffe is due the credit of constructing the first useful and reliable instrument.

Although it was recommended strongly by De Watteville, and also by Tripier, it was not generally used until Apostoli insisted that his treatments could not be intelligently given without it. Even now many physicians seem to think that it is only necessary in electro-gynæcology, but as essenteal as it is in this department, it is far more so in electro-diagnosis, and in its use in nervous diseases. It is as important as the graduate and balance of the apothecary, and, indeed, we may say no accurate or repeated dosage or treatment can be given electrically without it. A milliampere meter is an instrument whose deflections have a definite value.

A wire connected with the two elements of a galvanic couplet deflects a magnetic needle suspended over it. If the wire, instead of only passing under the needle, passes around over it also, the deflection will be greater, and if the wire be made into a coil, the deflection will be still greater. Such a coil with a needle suspended within it, is called a multiplier, on account of the added or accumulative effect of each additional

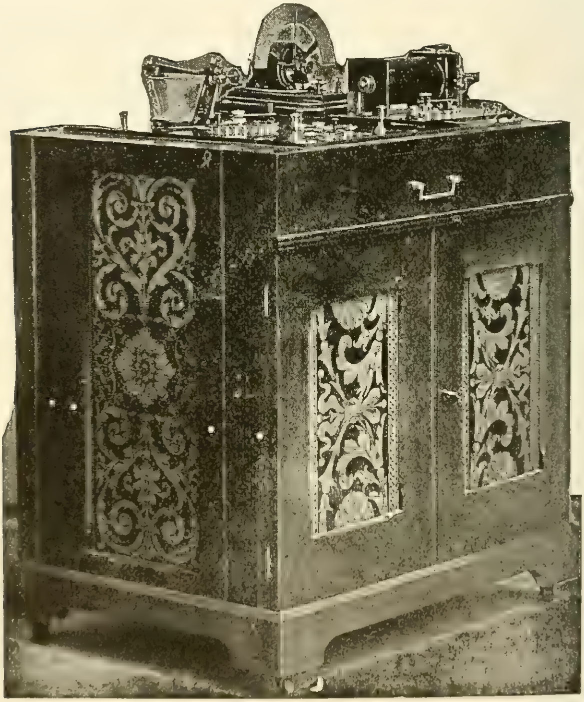


FIG. XXXII. Stationary Galvanic Battery.

coil or convolution of wire. By placing a card-board under the needle, on which to engrave or mark a scale, we have a galvanometer, which by proper calibrating may become a milliampere meter.

If we had access to a standard galvanometer, we might, by comparison, construct a milliampere meter by the grading of

a scale on any galvanometer, having the standard galvanometer and the one of unknown deflective value in the same circuit with any suitable battery, and a means of varying the current to produce deflection so that the needle of the standard instrument would rest over the divisions of its scale and marking the various positions of the new instrument at the same time.

Most meters have more than one scale. This is done to be able to measure a small amount of current on a scale sufficiently broad that divisions may be made of fractional amounts and at the same time capable of measuring a large amount. If this was all crowded into one scale, the sweep of the needle would be so broad that it would make the instrument unnecessarily large.

These two scales are usually made by means of what is called a shunt or by-path. For instance, if the whole amount of current which is passing through the circuit traverses the coils which influence the needle it deflects a long way. Yet only a small amount of current is passing and consequently the scale measures only a small quantity at its outer angles, thus giving space for small divisions. Now, if two conductors are formed for the current to traverse, one leading through the coils which influence the needle, and the other not, and there happens to be ten times the resistance in the former, only one-tenth of the current traverses it, consequently, the needle will deflect only one-tenth as far as it did before. By this means we are able to make another scale which will register larger quantities. In some meters two separate coils are used one made of a larger number of windings than the other with consequently greater deflections.

One very annoying thing is the oscillation of the needle after changing the current strength. To avoid this many devices have been used, such as air-vanes, paddles dipping in water, or alcohol and friction. Solid masses of copper, which, as well as several other metals, have the power of checking the oscillations on account of the currents set up by the movements of the magnets in close proximity thereto are also used.

The manner in which a milliampere is calibrated is to take a large constant cell, say one that has one volt of electro-

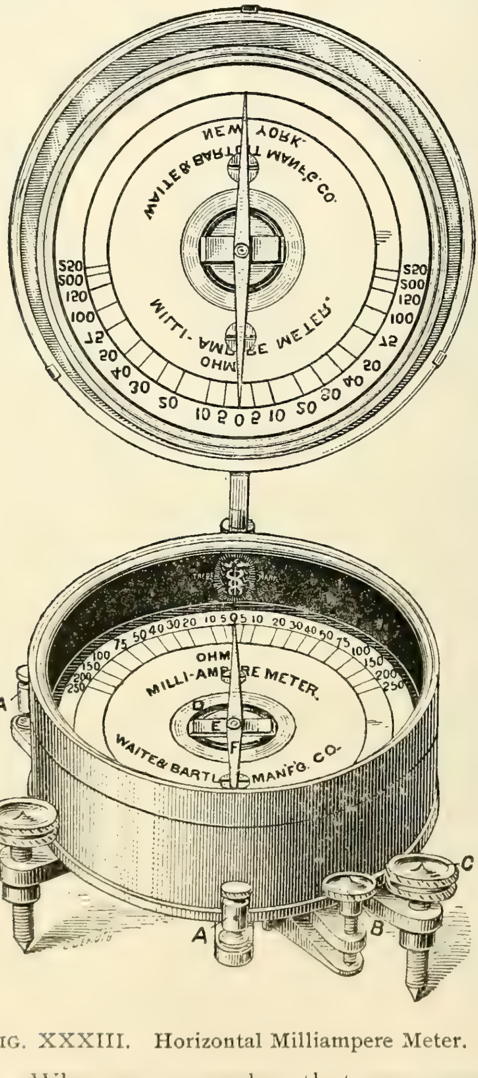


FIG. XXXIII. Horizontal Milliampere Meter.

motive force. When we remember that one ampere is one volt passed through one ohm of resistance, we find that one

milliampere is one volt passed through one thousand ohms of resistance. The resistance of the meter must first be ascertained. Say it is fifty ohms. With a rheostat in the circuit we introduce 950, 450, 200 and 50 ohms in the circuit and the current in each case will be $\frac{1}{950} + 50 = .001$, $\frac{1}{450} + 50 = .002$, $\frac{1}{200} + 50 = .004$, $\frac{1}{50} + 50 = .010$. In other words, we have 1, 2, 4, and 10 milliamperes. In this manner an ordinary galvanometer can be graduated into an accurate milliampere meter.

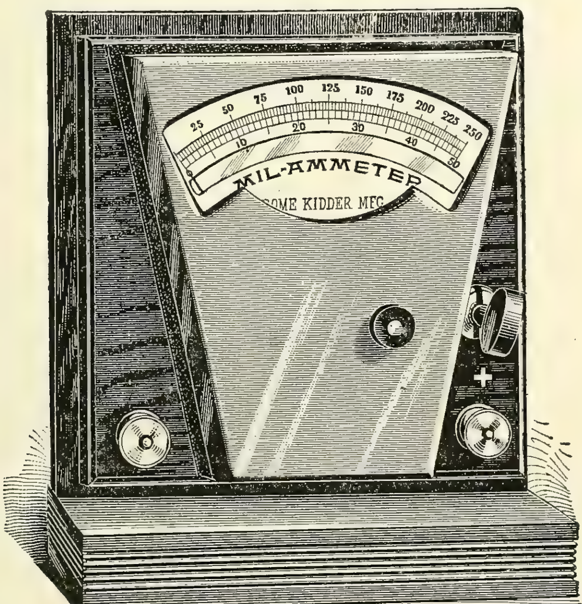


FIG. XXXIV. Upright Milliampere Meter.

There are two general forms of milliampere meters. In one the earth's magnetism is used to counterbalance the needle, that is, the needle is held in the magnetic meridian by the earth's magnetism, and the register is the amount of deflection from this meridian which the passing current produces. One of the greatest difficulties with magnets is that they are not permanent, that is, they change in magnetic power. If

now a magnet should lose say one-half of its magnetic power, the earth's magnetism exerts only one-half as much power on it as it did when it was full strength, but on the other hand, the current which goes through the coils and influences it only has one-half the influence on it; the deflection consequently is the same. It has been found that one mathematically compensates for the other, so in an instrument of this kind, no matter how much change takes place in the magnet, the instrument is correct providing the earth's magnetism remains the same. This, unfortunately, is not the case as the earth's magnetism changes slightly from year to year and in different places throughout the country, but such changes are comparatively slight and an instrument properly calibrated in one place is practically correct.

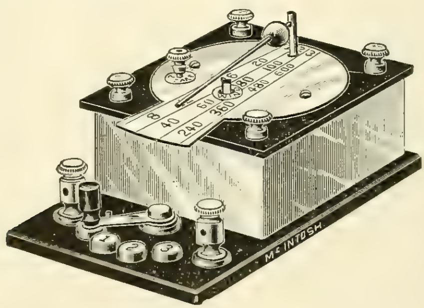


FIG. XXXV. Automatic Interrupter.

The other form of milliampere meter is where a permanent magnet is used as the counterbalancing force of the needle. If there is a change in the magnet in this instrument, it is mostly but not entirely compensated for, but on the other hand, the change in the earth's magnetism has no effect on it. Therefore, it matters but little the kind of meter, so long as it is properly calibrated and the mechanical construction is such as to give a perfect working instrument.

AUTOMATIC INTERRUPTER OF THE GALVANIC CURRENT.—This is an instrument which is placed at some point in the circuit and is so arranged that by automatic movements of a bar it constantly opens and closes the circuit.

There are two general classes of these automatic interrupters; in one the power which produces the vibratory motion of the interrupter is furnished by a spring, the same as the main spring of a clock or watch; the other is run by one or more primary cells. Of the two, the former is preferable, as it is less liable to get out of order and can be attached to a portable battery. The better class of automatic interrupters are constructed with a graduated scale so that interruptions varying from six to six hundred per minute can be employed.

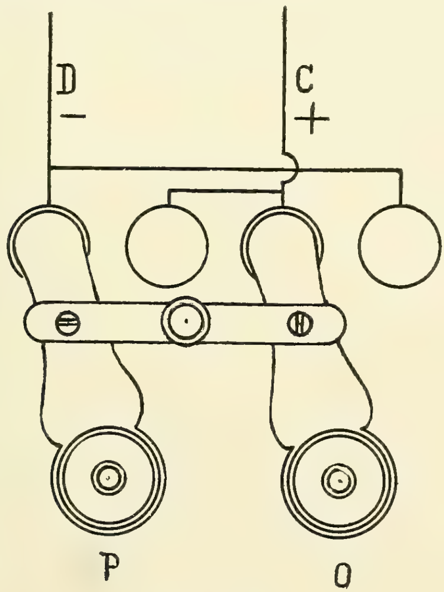


FIG. XXXVI.

A POLE CHANGER.—Very frequently, in the medical use of electricity, it is necessary to change the direction of the current. If this were to be done by changing the rheophores in the binding posts it would require much time, also there are therapeutical effects to be obtained by the shocks caused by the sudden reversal of the current with a pole changer. The pole changer is placed in the circuit between the cells and the binding post. By referring to Fig. XXXVI it will be easy to

understand the working of a pole changer. The two ends of the battery are shown at *D* and *C*; the latter is positive while the former is negative. The two wires are divided so that they are attached each to two buttons. As the switch now stands, the binding post *O* is positive and *P* is negative. If, now, the switch is turned to the right so that it rests on the other two buttons, binding post *O* will be negative and *P* positive, thus completely reversing the current at *P* and *O*. Pole changers may be made up in various styles but the principle is the same.

FARADIC BATTERY.—We have seen that one of the properties of the wire which connect the copper and zinc plate of a primary cell is induction, and it is this inductive property that gives us the battery that generates the faradic or induced current, which is simply an electro-magnetic machine. If we wind a coil of wire as thread is wound on a spool, the wire being covered with silk so that one turn or convolution may not be in contact with another, and then wind another coil in the same manner, having it large enough to slide over the first coil, and attach the two ends of the first coil to the plates of a primary cell and the two ends of the second coil to a galvanometer, we find that when the second coil is rapidly placed over the first, the galvanometer needle is deflected, but it immediately returns to zero, where it remains until the second coil is suddenly removed, when the needle is again deflected but in the opposite direction. This first coil is known as the primary coil and the second or outside coil as the secondary. If this secondary coil is very slowly placed over the primary there will be but little, if any, deflection of the galvanometer needle, and the same is true if it be very slowly withdrawn. If, after the secondary coil has been placed completely over the primary and allowed to remain there until the needle comes back to zero, the primary circuit be suddenly broken by disconnecting one of the wires that connect the cell with the primary coil, the needle will deflect much farther than when the secondary coil was suddenly withdrawn from the primary, for the breaking of a metallic contact is more sudden than the change produced by moving one coil over the other.

It is, therefore, evident that the current in the secondary coil owes its existence to variation in force in the primary circuit, and also the more sudden this variation, the greater the secondary or induced current. If we have a galvanometer in the primary circuit as well as the one in the secondary or induced circuit, we will find when the primary circuit is made by connecting the wires of the cells with the primary coil the two galvanometers will register currents traversing in opposite directions, and when they are broken, the one in the primary circuit will return to zero, while the one in the secondary will swing in the same direction as the one registering the primary current when the circuit was closed. This is due to the fact that an induced current always travels in an opposite direction to the inducing current. When the current suddenly rises in the primary circuit or coil, the induced current is in the opposite direction; when the primary circuit is broken the current suddenly recedes, the current in the secondary or induced circuit suddenly reverses, travelling in the opposite direction or in the same direction as that of the rising primary current. We may further intensify the deflection of the galvanometer needle of the secondary circuit by placing inside the hollow primary coil an iron bar or a bundle of small iron wires known as a core, completely filling the opening. The action of the iron core is first to concentrate the lines of force set up by the coils of wire as a lens concentrates rays of light. Currents are also set in action or induced in the iron core itself, which on being rapidly demagnetized by the breaking of the connections with the battery greatly increases the strength of the induced or extra current momentarily set up in the coils.

If, after filling the primary coil with the iron wires, we take in our hands the ends of the wire of the secondary coil and then attach the ends of the primary coil to our battery cell, we shall perceive little or no sensation, but if, having once closed the primary circuit as stated, we suddenly break the connections of the primary coil with the battery cell, we will receive a decided and disagreeable shock, and if the coils are of sufficient size contractions of the muscles in the arms and

hands will be produced. The reason for this is, the two currents which traverse in opposite directions in the secondary or induced circuit are of a different potential. They both have the same quantity but the voltage is far greater in that of the opening current or the one which traverses in the same direction as the primary when it is closed. This is due to the fact that the variation stage to which it owes its existence is more sudden than the closing circuit and its physiological effects are proportionately greater as is its voltage.

While, as has been seen, the induced current is a to and fro current travelling in both directions, we are accustomed to speak of it travelling in one direction or the direction of the

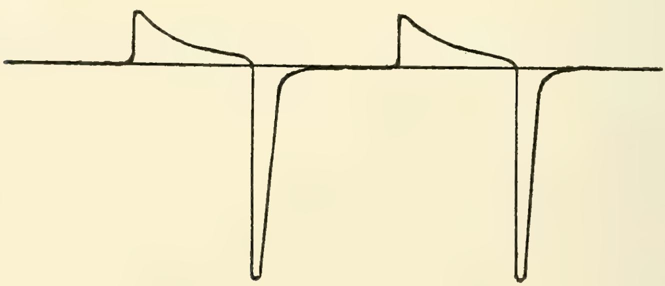


Fig. XXXVII.

opening current, which is also the direction of the primary current. This statement, however, needs a certain amount of qualification. The quantity of the discharge given off in each direction must be equal, the only difference being in the voltage, owing to the rate of discharge. If there were no external resistance, each discharge would have equal electrolytic effect; but as the external resistance increases, the one with the least voltage lessens in its effect more rapidly than the one with the greater voltage. When the resistance reaches a point where the one of lower voltage or the one produced by the make of the primary circuit is incapable of overcoming it, we obtain the action of only the one having the greater voltage. Fig. XXXVII illustrates these points. The long drawn out curve above the line represents the one of low voltage or the impulse

from the make current, while the short but sharp curve below the line indicates the rapid but short impulse of the discharge of the break current, the space between this and the next make representing the period of rest. It will be seen by this diagram that the faradic current is made up of impulses which run in cycles and is not therefore rhythmical.

The interruptions in the primary circuit are made by means of an automatic interrupter known as the vibrator or rheotome. The connection of the primary coil with the cell is by way of the post at the left in Fig. XXXVIII, thence to the flexible spring *a*, and from the spring to one end of the primary wire, the remaining end of which is attached to the other element

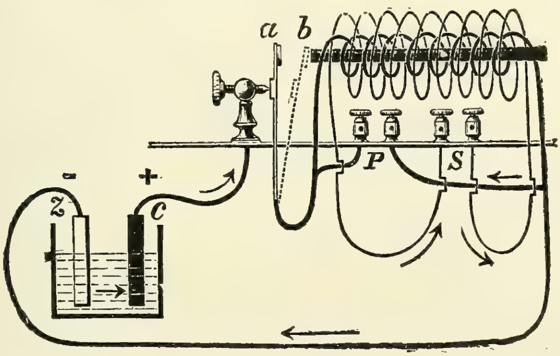


FIG. XXXVIII.

or plate in the primary cell. If the cell is in working order, a current traverses the primary wire in the course just mentioned, and, as it rotates around the iron core, that becomes strongly magnetized. The spring, having a piece of iron affixed to its free extremity, is attracted toward the end of the iron core of the primary coil at *b*, until it breaks its connection with the end of the screw, thus breaking the circuit and the current ceases to flow from the cell. At the same instant the magnetism in the core ceases, and the spring, by its own resistance, returns to its original position in contact with the point of the screw, when the circuit being again made, the spring is again attracted, the circuit is again broken and the

spring flies back again, and so on. This is repeated very rapidly, and the rapid making and breaking causes the extra current to give those shocks that in rapid succession constitute the faradic current. The windings of the fine wire in this cut represent the secondary coil. Shocks may also be obtained from the primary coil but they are much weaker than those from the secondary.

The strength of these shocks may be varied in five different ways: First, the shocks are decreased by removing the iron core and strengthened by replacing it; second, by placing a brass or copper tube over the iron core; third, by placing a metal tube between the primary and secondary coil, and fourth, by placing a metal tube over the secondary coil. In the last three cases the shocks are strengthened as the tube is withdrawn and lessened as it is replaced over the coils. If this tube was slotted its entire length so that it was not a complete circle, it would have no effect on the strength of the shocks. In all of the above cases the primary and secondary currents are affected in the same manner. Fifth, the shocks are modified by the distance the secondary coil is placed over the primary. The shocks from the secondary coil are much greater when it is placed over the entire length of the primary, and will be gradually lessened as the secondary coil is withdrawn. If the two ends of the secondary coil are not connected it has no influence whatever on the primary coil, as that acts the same as the slotted tube; but when they are connected, the shocks of the primary coil are greater as the secondary coil is withdrawn and less as it is replaced. On this last principle the Du Bois-Raymond coil is made.

It is important that we fully appreciate the different qualities of current produced by the different size and length of the wire used in the construction of the secondary coil. In the ordinary transformer the amperage and voltage differ according to the windings of the secondary coil. When a large sized short wire is used, the voltage is low and amperage great and when the wire is of small section and of great length, say if six thousand feet are used, the voltage is great and amperage

small. These different manifestations of the current have different physiological and therapeutical effects which will be given in their respective sections.

Some makers use three distinct spools for winding the secondary coil, while others wind the three lengths on one spool,

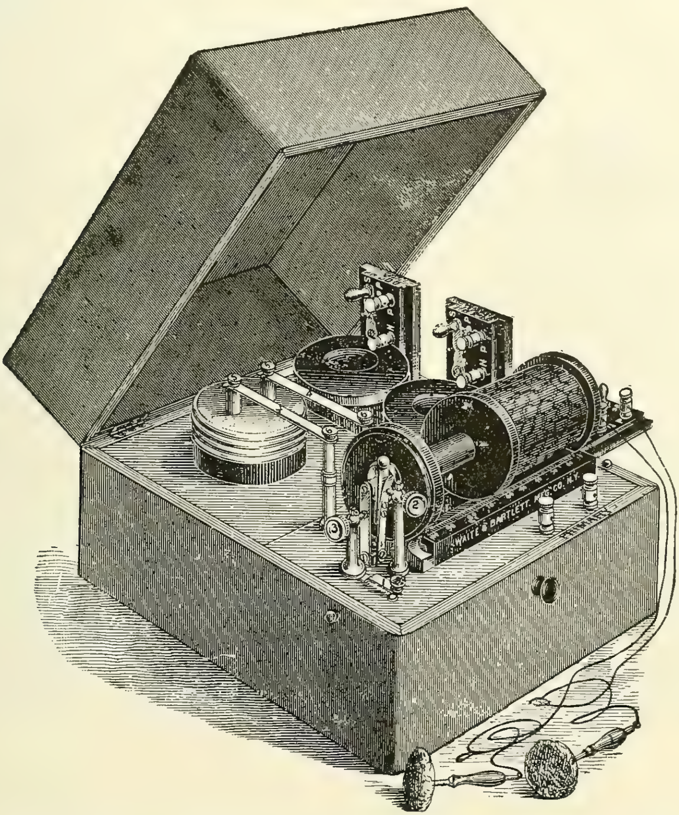


FIG. XXXIX. Faradic Battery with a Seperate Spool for each Secondary Coil.

but use two single arm switches to connect the two ends of whatever section needed, which gives the same effect as though the one selected was the only one on the spool, for unless the two ends of a secondary coil are connected no induction takes

place. The wire generally used is made of No. 22 Brown & Sharpe's gauge for the coil of quantity, No. 32 for the medium coil and No. 36 for the coil of tension, this last coil having a length of from 4500 to 6000 feet.

There has been much discussion regarding the measurements of the faradic current but no satisfactory conclusions have been reached. Its action on the human body depends upon the size of the wire with which the coils are wound, the number of turns and the number of vibrations per second; in

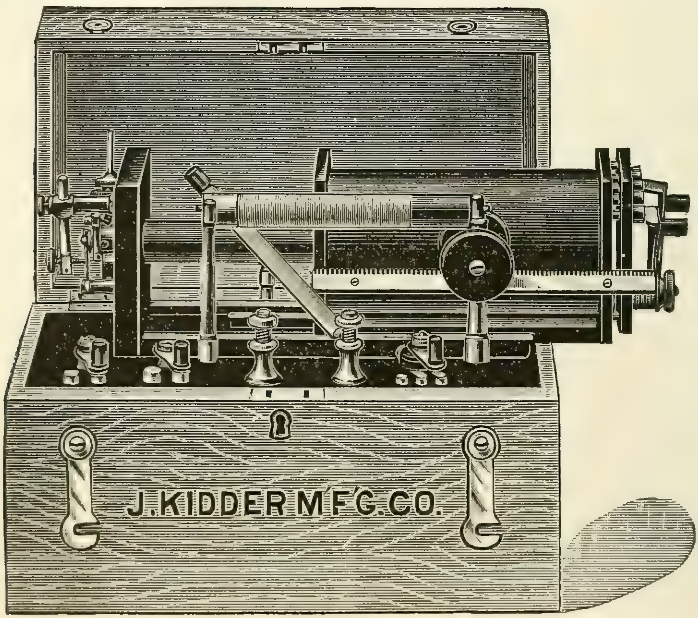


FIG. XL. Faradic Battery with One Spool for the Three Coils and Having Two Single Arm Switches.

fact, so many circumstances enter into its physiological action that no scientific instrument as yet has been devised to measure the amount of current developed from an induction coil.

LARGE INDUCTION COILS FOR X RAY WORK.—These coils differ in no essential from the faradic coil just described except that they are made very much larger so as to

furnish a great force or potential of current. As this potential reaches into the thousands of volts, great care must be exercised both in the making and the handling of them. The insulation of the wire must be the most perfect and the coil must be wound with great care and precision. There has always been difficulty in the working of these coils on account of the spark produced at the break in the primary circuit. Of course the greater the amperage the greater the spark and oxidation at contacts. Various devices have been placed upon the market to overcome this defect such as rotary interrupters, and blowing a current of air across the contact point. The latter, the device of Mr. Thomas A. Edison, was more or less successful, but it came far from entirely obviating the difficulty.

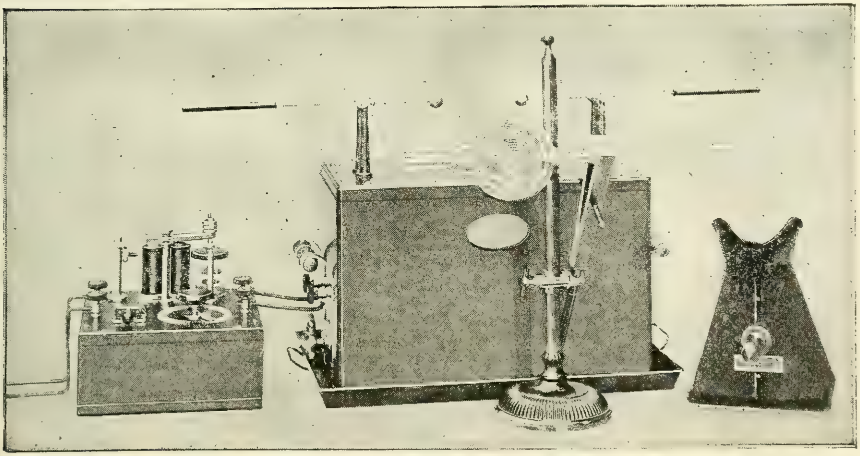


FIG. XLI. Large Induction Coil for X Ray Work, Inclo ed in a Case for Protection.

Wehnelt of Germany has lately discovered what he terms an electroytic interrupter. This consists of two electrodes, one a very large one generally made of lead, and the other a very small one, generally a small platinum wire immersed in a vessel containing some electrolyte, preferably a dilute sulphuric acid solution. Two theories are at present in vogue regarding the action of this strange little instrument. One is that by the process of electrolysis bubbles of hydrogen collect

in large numbers around the platinum point and explode, thus throwing the fluid away from the contact and breaking the circuit, when the rushing back of the fluid makes another contact and another explosion takes place and so on. Another theory is that the great heat developed at this point generates steam which acts in a similar way as has been ascribed to the hydrogen. Whatever may be the *modus operandi* of its working, this instrument certainly possesses great merit and has made the coil far more effective in X ray work than it was before its invention.

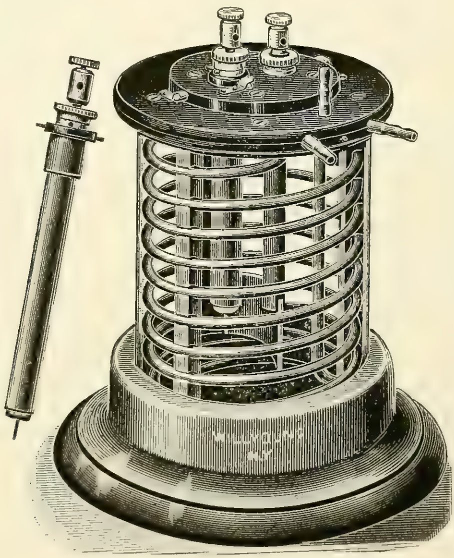


FIG. XLII. Wehnelt Interrupter.

We need not here discuss the comparative merit of the coil with the static machine for X ray work. The coil possesses a special advantage in being portable; it can, without much trouble, be moved to the side of the bed in case of a fracture of the femur or other bones, when the patient cannot well be moved, and it also possesses another advantage in that it will work in all kinds of weather with equal force. It, however, has no superior merit over the static for X ray work and as

most electro-therapeutists possess a static machine, it is quite probable that X ray work done by physicians will be largely done with the static.

GALVANO-CAUTERY.—If we go back to the simple couplet of zinc and copper immersed in dilute sulphuric acid, connected at the top by means of a wire, we find that somewhere in the circuit, heat is generated, and this will be most manifest at the point where the resistance is the greatest. If the elements are connected by a large copper wire, which offers but very little resistance, the heat will be manifest inside the cell, for the resistance in the column of fluid between the elements which act as the conductor, will be greater than at any other place in the circuit. In a short time the fluid will become very hot. If, however, we substitute a small platinum wire which offers comparatively great resistance, as against the large copper wire, we find that the heat is manifest in the platinum wire. If we lengthen the platinum wire to such an extent that the resistance is greater than the electro-motive force of the cell, we get no heat as the force of the current is exhausted in its effort to overcome the resistance. Therefore, in those cases where we wish to heat a long platinum wire loop, we must have electro-motive force enough to overcome the resistance. This is generally done by having the battery so constructed that it can be connected in multiple for quantity, say in one or two cells when a cautery knife is used, and in series for intensity when it is desirable to use a long loop or ecraseur.

As heat is developed where there is resistance and it is very desirable not to create heat inside the battery, the cells are constructed for cautery work, so that but very little resistance is offered within them. This is accomplished by using large plates so as to have a large surface to conduct, and also a number of plates in one cell placed closely together, and so connected as to have the same effect as if two enormous plates which contained the aggregate of all were used. For the same reason very large sized rheophores or conducting cords are used, as the larger the cord, or the larger any wire, the less

the resistance; therefore, the only point in which there is any material resistance is at the platinum point or loop. Although the platinum point or loop offers considerable resistance in comparison with other parts of the circuit, it is very small when compared to the resistance of the human body, making it necessary to employ but a fraction of the electro-motive force, even with the longest loops in electro-cautery work,

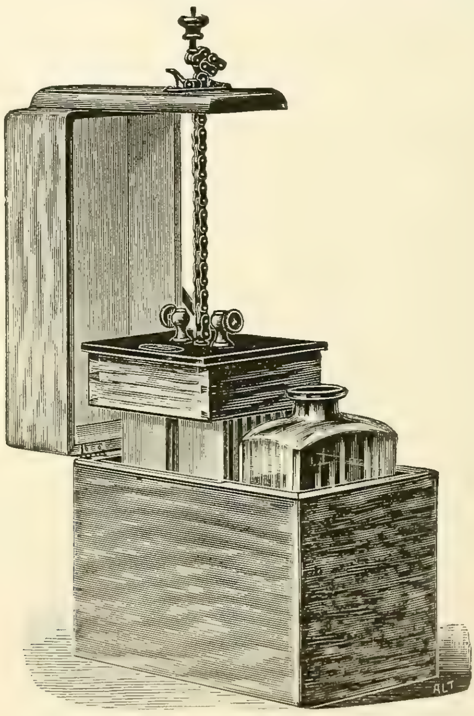


FIG. XLIII. Acid Cautery Battery.

that is required in electro-therapeutics. Cautery batteries do not, therefore, need the number of cells that a galvanic battery does. They are generally constructed with from two to six cells. When there is such small resistance in the circuit, polarization is liable to take place by the collection of bubbles of hydrogen on the carbon or platinum plate. This is over-

come by mechanical arrangements which permits the elements to be moved in the fluid, there being openings in the zinc plates which allows the fluid to circulate through them, striking the negative plate at an oblique angle and washing off the bubbles of hydrogen as they form. Another device is to force air into the cell by mechanical means so as to cause a movement of the fluid about the plates.

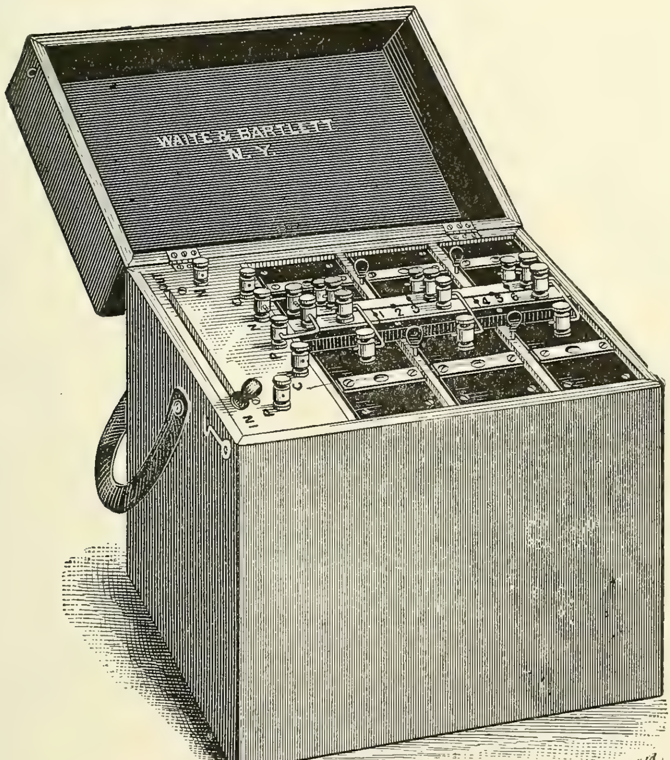


FIG. XLIV. Accumilator or Storage Battery.

The accumulator or storage battery has of late been used largely for cautery work. Its disadvantages are in its great weight and a liability to exhaust at a critical moment. The advantages it possesses over the ordinary acid cautery battery

are so many that it is far more preferable for all cautery operations, especially those which require a large quantity of electricity continued for some time. Before using the portable cautery battery, the zincs should be well amalgamated and the binding posts cleaned; the cautery tip which fits into the handle where contact is made and broken often needs cleaning, especially if the handle has not been used for some time. In fact every contact should be examined. The elements should not be lowered into the fluid until ready for use, and should be removed from the fluid as soon as possible after using and immediately washed in clean water. The fluid should be thrown away and the cells washed. If the battery in operation hisses and gets very hot, the zincs are not thoroughly amalgamated. All connections should be more perfect than in a galvanic battery, as the current has little power to overcome the resistance of imperfect connections. There are some cells on the market, chiefly the Edison-Leland cell, which are capable of giving off a large quantity of current and continue without decreasing in strength for a long time. These cells, however, are very large, and cannot be carried about, but as a stationary battery, they answer the purpose very well.

As will be seen later, the best cautery is to be derived from street electric light circuit, but, unfortunately, not all physicians are so located that they can tap a street circuit, and, consequently, must depend on a battery of some kind. Although it has long been known that different degrees of heat produce quite different effects on tissue regarding hemorrhages, contractions, etc., the idea of measuring the galvano-cautery current, had hardly been thought of, until Dr. Freudenberg revised the Bottini operation.

Here the cautery knife is so entirely out of the sight of the operator that unless the current is measured, no idea can be obtained as to the degree of heat that is being used, or how much actual destruction of tissue is taking place. As the quantity of current used is large when compared with the galvanic, it is not necessary to divide the ampere by the

thousand. The quantity of the current is therefore measured in amperes, and a perfect cautery instrument should be one from which from two to fifty amperes may be obtained. An ammeter is not an expensive instrument, and may be had from electrical manufacturers the same as the milliampere meter. When performing the different cautery operations, it is of the greatest importance to know just the degree of heat that is being used. This cannot always be told from sight, as the loop or knife may be burned into the tissue out of sight even though the part operated on be in plain view. It is, therefore, to be

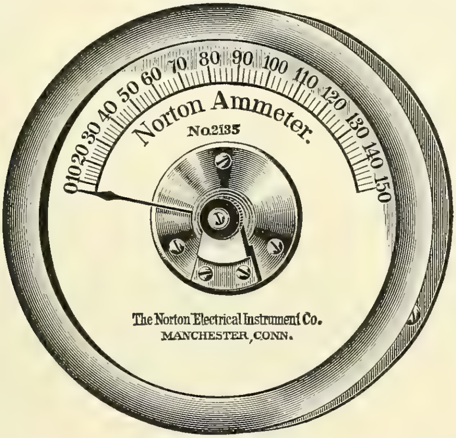


FIG. XLV. Ammeter for Measuring Either the Direct or Alternating Current.

hoped that the use of the ammeter will come more into use, and that the effects of certain grades of heat may be more carefully studied.

A CURRENT CONTROLLER FOR USING THE ELECTRIC LIGHT CIRCUIT.—It should be understood that not all electric light circuits are available for medical purposes. While the alternating current may be used for the galvano-cautery, it cannot be employed for a galvanic current which must always be direct. An alternating current, however, may be used to run an alternating current motor, which in turn may run a small dynamo generating a direct current. The

higher voltage circuits that are used for the arc light are not available, as the resistance which is necessary to reduce the currents to the required force is very great. Therefore, we must have a current which is direct, that is running in one direction, and which has a comparatively small voltage. The current used in the Edison system of incandescent electric lighting can be utilized, providing it is delivered through the circuit during the daytime. This is a direct current and has a pressure of about 110 volts.

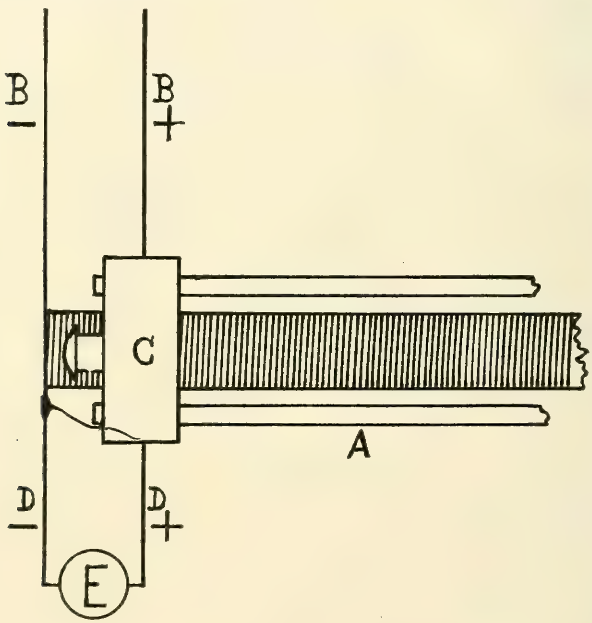


FIG. XLVI.

If a current is passed through two conductors, say two copper wires instead of one, and these wires are of the same length, size and composition and consequently have the same amount of resistance, the current will be equally divided between the two. If, now, we lengthen one of the copper wires so as to increase its resistance there will be correspondingly less current passing through it and proportionately more

through the other which has less resistance. If we have recourse to Fig. XLVI we can more easily comprehend the principle and mechanism of an instrument constructed for utilizing the electric light current. The drum *A* is wound with a coil of German silver wire. *B*+ *B*—, are the wires leading from the electric light circuit and are accordingly positive and negative. The negative is attached directly to the end of the coil of wire, while the positive is attached to a slide *C* which has a metallic connection with the German silver wire. *D*, *D*, represents the rheophores and *E* the patient. Now, if the slide *C* is placed adjoining the end where the negative wire is attached there will be no resistance offered, and the current will pass through the positive wire *B*+ and return through the negative *B*—. Now, if *C* is moved along the coil so that some resistance is added between it and the end where the negative wire is attached, some current will be forced through *E* by means of the rheophore *D*+ and return by *D*—. When *C* has been moved along the resistance coil a sufficient distance so that the resistance on the drum between the two poles at *A* is equal to the resistance offered at *E*, half the current will pass each way. This device is known as a shunt or by-path. By this means we are able to graduate a current of large voltage as evenly as with the ordinary galvanic battery.

In large cities where the underground system of wiring is used there is not much danger, but in smaller cities and towns where the overhead system is still in use, and where the wires conveying a current of 110 volts are crossed by wires carrying a much larger current, the liability to accidents by the two wires coming in contact, even at a remote distance from the office, thus sending a tremendous voltage through the circuit which the patient is in, is sure to do serious damage. Men who work on telegraph and telephone wires where the voltage is so extremely low that the wires may be handled with impunity, are often killed by accidents of this kind. Before the wires of the arc light system were put under ground in this city (New York) the papers were almost weekly chronicling

deaths from similar accidents. Makers of this kind of controller strive to overcome this possible danger by putting somewhere in the circuit a fuse which will melt, and thus disconnect the circuit when currents are increased to 200 volts. The fault with this is, that electricity is much quicker than the

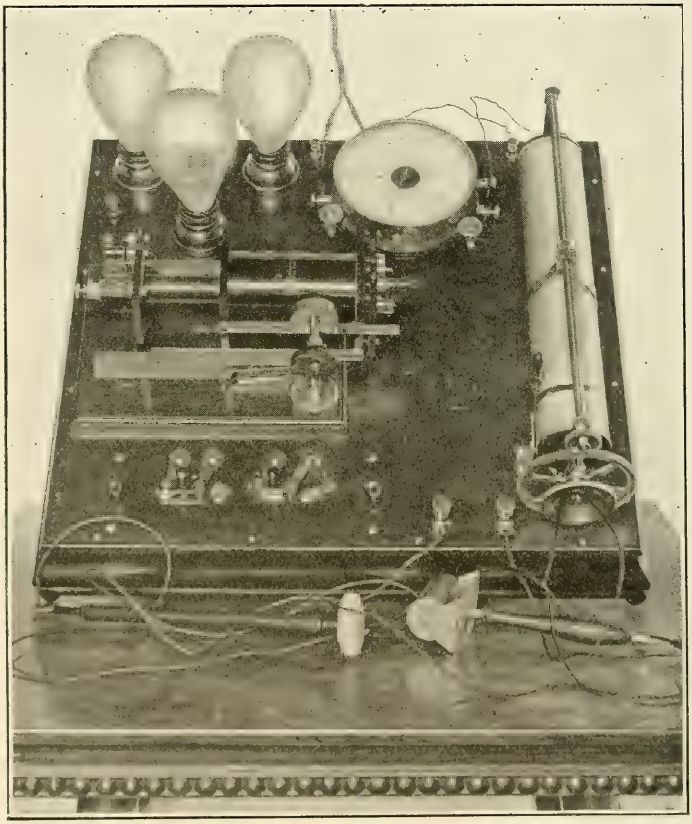


FIG XLVII. A Current Controller for Utilizing the Electric Light Current.

fuse and before the fuse has melted it has conducted the current. To be sure it is only momentary, but it is long enough perhaps to kill the patient if the current has been of sufficient voltage. For this reason some have advocated another method

of utilizing the street current, which is perfectly safe under all conditions. They carry the current from the main to a small motor which in turn runs a small dynamo of low pressure, say 60 volts, which may be controlled with the same ease as can the voltage from an ordinary battery of cells. This may no doubt be made a most perfect instrument, but we have never seen one which gave off a particularly smooth, even current.

Another objection to the use of the electric light current is that there seems to be more pain when it is used in the same strength, as registered by the milliampere meter, than when a smaller voltage is used. It would seem that if the same strength of current was passed through the body of the patient, other conditions being equal, there should be an equal amount of pain; this, however, according to our experience, as well as many others, is not always true, particularly if the current is suddenly turned on. Always when large currents are cut down and the circuit is suddenly closed, as in applying the electrodes suddenly to the body, or introducing a needle into a hair follicle—when the body is connected with the other pole—there is an extra rush of current. When the circuit is first made the milliampere meter needle momentarily swings further around than when only a few volts are in the circuit, although the needle may finally rest on the same point. It is supposed that this extra rush of the current produces the extra pain, and to avoid it care should be exercised to very slowly increase the current strength. It is found also, that the pain is more marked when the resistance is all in one place, than when it is divided and put into different parts of the circuit.

The most perfect instruments of this kind are made by first cutting down the current strength to fixed portions, and then controlling this reduced current by means of a shunt. The best resistance is an electric lamp. A sixteen candle power lamp has a resistance of 240 ohms. Now, if we apply Ohm's law we find that if we tap a 110 volt circuit with this lamp in series we get .5 of one ampere or 500 ma., and if two lamps are placed in series we get .25 of one ampere or 250 ma. This may be arranged so that by the insertion or removal of a

plug we may obtain 500 or 250 ma., as we may need a larger or smaller amount of current. Seldom, however, is more than 250 ma. required, and it is better to have the lamps arranged permanently in series, one on either side. This 250 ma. is then passed into the shunt where it is controlled with great ease and smoothness.

ADAPTATION OF THE ELECTRIC LIGHT CURRENT TO THE FARADIC BATTERY.—There is no difficulty in adapting the 110 volt circuit to a faradic battery. If the coil is made especially for the 110 volt circuit it is better that the primary coil should be wound with sufficient resistance as not to require any other resistance in the circuit. When, however, a coil is wound for low voltage, lamps or other resistance may be placed in the circuit to cut it down to the required intensity. It is possible to obtain a smoothness of current from a faradic coil in this way that cannot be obtained with the ever varying electro-motive force of cells.

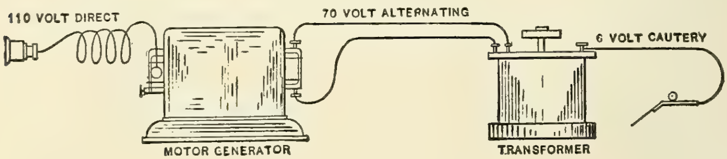


FIG. XLVIII.

ADAPTATION OF THE ELECTRIC LIGHT CURRENT FOR CAUTERY WORK.—There are two ways of utilizing the direct electric light current for cautery purposes. One method is by tapping the circuit with large lamps placed in multiple. Take for instance a 150 candle power lamp which has a resistance of 27.5 ohms. Now, according to Ohm's law when this is placed in the circuit 4 amperes are given off. If five lamps are placed in multiple 20 amperes are available and ten lamps in the circuit gives us 40 amperes. There are, however, great objections to this method. Few houses are wired for so large a current, it is very expensive and a large current is not altogether devoid of danger. Another method is to utilize the direct current to operate a

motor generator giving off an alternating current. This alternating current thus generated, Fig. XLVIII, is passed through the primary coil of a transformer which has a secondary winding of short thick wire giving off a current of low voltage and large amperage. By tapping the winding of the secondary at intervals, by means of a collector, any degree of heat from the lowest to the highest required is easily obtained. When

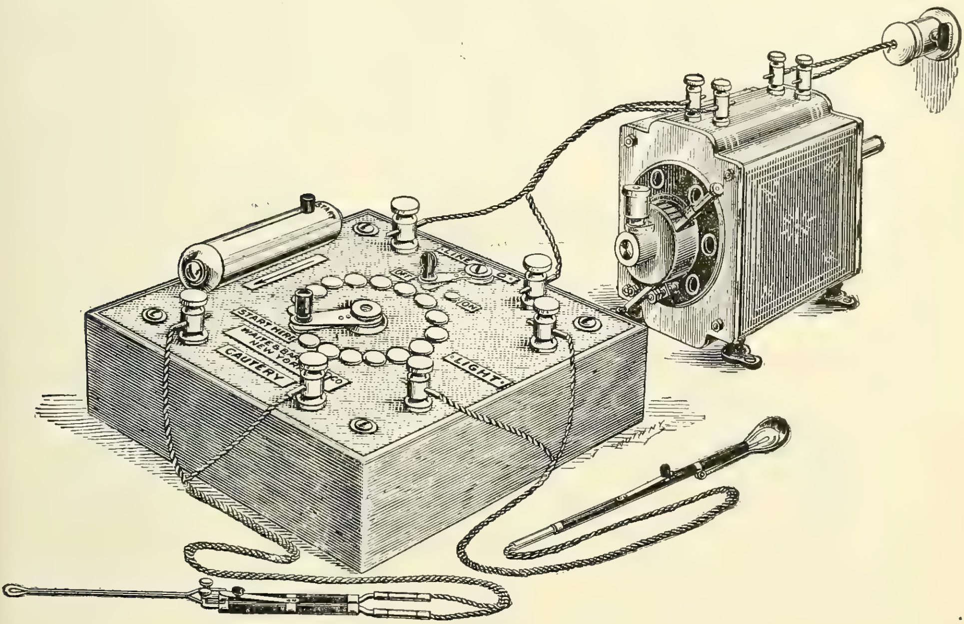


FIG. XLIX. Motor-Generator and Transformer for Utilizing the Electric Light Current for Cautery Work.

an alternating current main is available, the problem is a simple one, since all that is required is to simply connect it with the transformer. An objection has been raised to the alternating current on the ground that it could not be accurately measured, which is so essential for the Bottini as well as other large cautery operations. But this can no longer be maintained, as there are instruments now to be had that measure it

quite as accurately as the ordinary ammeter does the direct current.

Quite recently a current sufficient to heat very small knives has been obtained from the direct current by placing a Wehnelt interrupter (description of which is given under larger induction coils for X ray work) in the circuit. So far as we

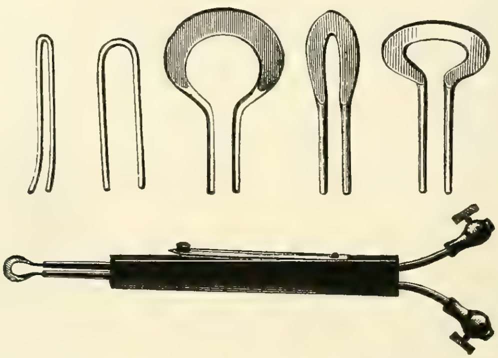


FIG. L. Cautery Handle and Knives.

have seen this method work, it will only be suitable for small operations, such as the throat and nose, as the quantity is not sufficient for heavy operations. It may, however, be so improved that in the near future it will meet every demand.

SINUSOIDAL CURRENT.—The galvanic current, as has been seen, is a continuous flow of the current through the circuit from the positive to the negative pole. But with the

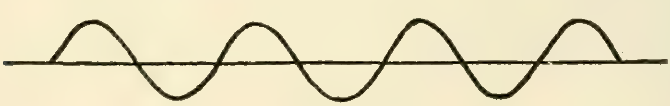


FIG LI.

alternating current, as its name implies, the polarity is changed and the current is alternated and caused to flow in each direction to and fro. Alternating currents differ very much in their tracings. Some produce more or less sharp angles, others very irregular angles, while another, if the instrument is perfect, will produce an even curve above and below the neutral line,

as is shown in Fig. LI. These curves are known to mathematicians as sine curves, and thus the term sinusoidal current has been applied to a true alternating current, giving the sine curve in its tracings. A pole changer worked rapidly by some mechanical device, and placed in a galvanic circuit will produce an alternating current, which may resemble a sine curve provided the pole changer be so constructed that there is a gradual rise and fall of the current strength. There has been an instrument invented in which the alternator is immersed in a bath. This probably gives the truest sinusoidal current of any machine known as it is doubtful if such can be obtained

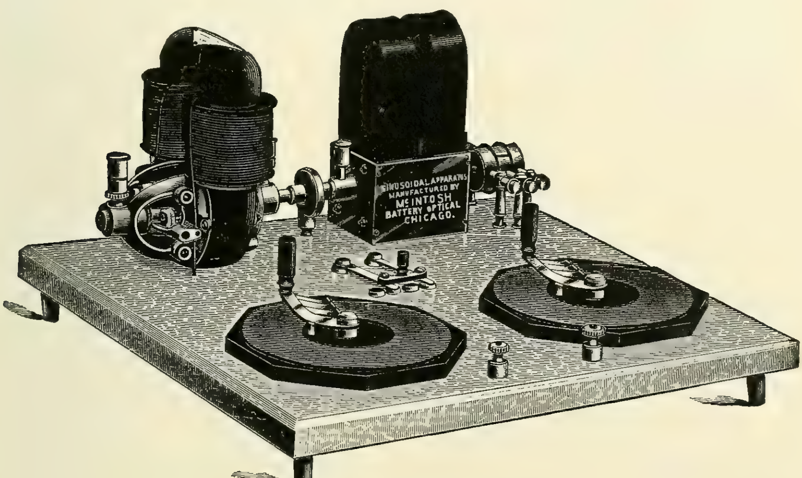


FIG. LII. Sinusoidal Machine.

when we rely upon iron and magnetism. The instrument mentioned, however, is incapable of rapid alternations. Some alternators have several poles giving off alternating currents from each, and may be called multiple alternators.

The old magneto-electric machine gives an alternating current of this type, but it is not a true sinusoidal current. Here one permanent horse-shoe magnet is employed, and coils wound on soft iron cores are made to revolve in close proximity to the two poles of the magnet. As one spool approaches a

pole of the magnet, a current is generated running in a certain direction in the coils of wire. As it is leaving the magnet, another current running in the opposite direction is generated. It is apparent that there is a succession of currents running in opposite directions given off from the spools at each revolution made. Now, if there was an arrangement of many magnets, and a corresponding increased number of spools, there would be a corresponding increased number of alternating currents given off. The quality of the current generated varies with the size and length of the wire of which the spools are wound, being of larger quantity and smaller potential when a short thick wire is used, and smaller quantity and greater potential when the spools are wound with a long thin wire. The strength of current is graduated first by the strength

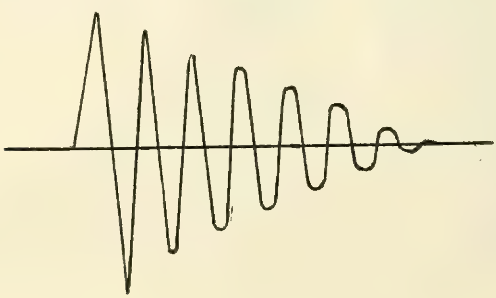


FIG. LIII.

of the magnet and, second, by the speed with which the armature is made to revolve. There are other machines in which electro-magnets are employed instead of permanent magnets. This machine has the advantage over the one of the permanent magnet, inasmuch as the strength of the current can be graduated by the strength of the electro-magnet.

HIGH FREQUENCY CURRENT.—A high frequency current is an alternating current which has a very rapid rate of alternations. So rapid are the alternations that the term oscillatory or high frequency have been applied to them. A high frequency current must have a very high electro-motive force and a very small quantity. Another characteristic of

this current, besides its high frequency, is that it rapidly disappears as shown in Fig. LIII. High frequency currents may be produced by the discharge of a condenser such as a Leyden jar through a small inductorium in the circuit. In order to obtain the highest rate of oscillations, the discharge must be from a not too large condenser and through a small inductorium. A discharge from a pint sized Leyden jar through a small inductant will produce a much higher frequency of oscillations than would a discharge from a quart sized Leyden jar through a correspondingly large inductant. On the other hand, however, the amplitude of the vibrations from the large jar would be much greater, and the amount of discharge would, of course, be correspondingly greater. It seems that a large quantity of current acts as a dampener on the frequency of oscillations just as a weight attached to a pendulum acts as a dampener on the frequency of its oscillations. An idea may be had of the enormous rate of these oscillations when it is estimated that the discharge from a Leyden jar of a pint size, when only a short thick wire is used to connect the external and internal coatings, is 15,000,000 of periods per second. It is possible that as we learn more regarding the physiological and therapeutical action of this current, we will find, that the discharges of very high frequency and small amplitude, and those of less frequency and greater amplitude, have each different effects. It is quite probable that the former acts more upon the integument, while the latter has a deeper seated action. It has been claimed, that inasmuch as this current remains on the surface of metals, it acts only upon the skin when applied to the body. This is not a logical comparison as the conditions are very different. The same has been claimed many times in regard to static electricity, but it is very easy, by the discharge of a static spark, to reach the deepest seated motor point in the body as evidenced by the vigorous muscular contraction which is produced. On this point we quote from the well known authors Houston and Kennelly:

"It has been suggested," say they, "that alternating currents of such high frequency would be unable, in traversing

the human body, to penetrate more than a very moderate distance below its surface, and that, therefore, only superficial portions of the body could be directly affected by the discharge. Owing, however, to the feeble electric conductivity of the materials of the body, this skin effect, or tendency of the current to seek the outer layers to the exclusion of the inner layers, is comparatively small at the frequencies which can be practically produced, for, while the depth to which such cur-

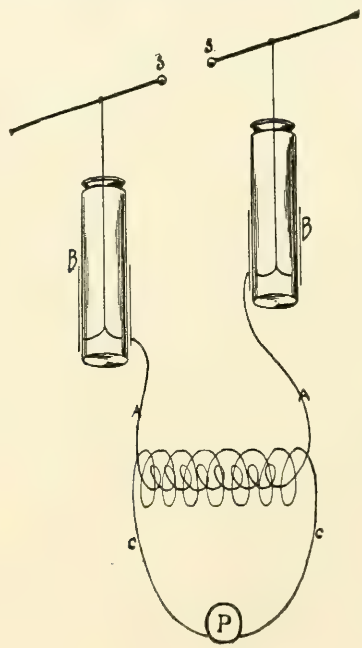


FIG. LIV.

rents would penetrate in good conductors, such as copper wires, is very small, yet in the case of comparatively high resisting materials, such as those constituting the human body, the penetration would probably extend practically through the entire mass. High frequency alternating currents are, therefore, powerful but painless currents, and are, probably, attended by electrolytic effects in the entire mass, although, as

in the case of all alternating currents, little if any accumulation of electrolytic materials can take place."

The method of producing high frequency currents for medical use is by discharging the condensers—Leyden jars—through a small inductorium. Fig. LIV represents a high frequency apparatus. The Leyden jars, *B B*, may be charged

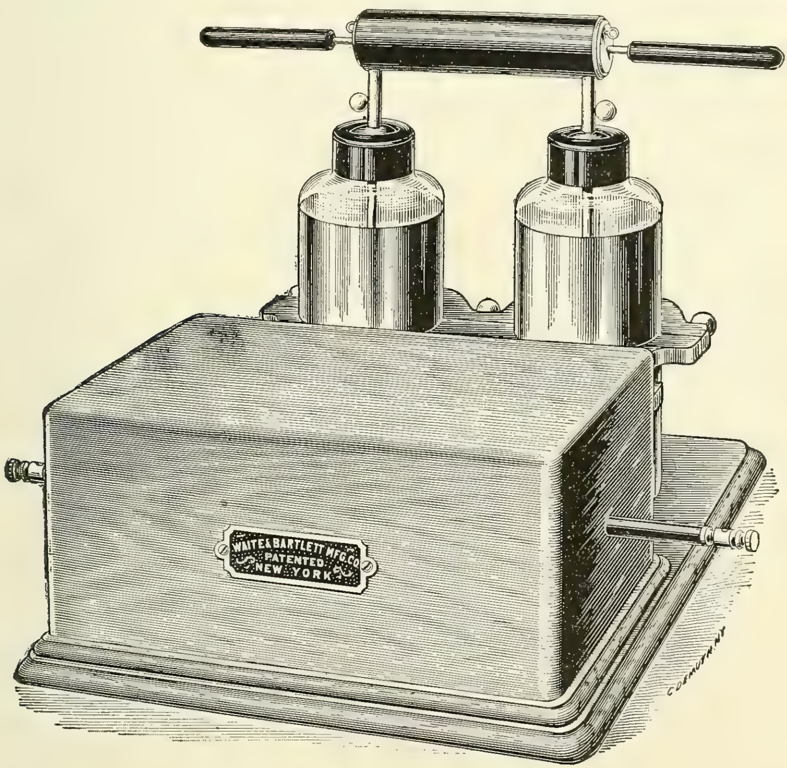


FIG. LV. High Frequency Battery.

from a static apparatus or from a coil, or any other source which gives off a charge of sufficient potential. As most electro-therapeutists possess a static apparatus, this is easily managed. As the jars become charged with a sufficient electromotive force to overcome the resistance of the air-gap at *s. s.*

a spark passes, emptying the jars. This releases the charge from the outside coatings which rushes through the conductors *a. a.* to the primary coil. This coil is made up of only a few turns of wire, and the secondary coil, which is wound over it, is composed of only a few more turns than the primary coil contains, being separated from it by a tube of pure Bohemian glass to prevent sparks passing between the coils. The insulation of the wire must also be very perfect. In very large apparatuses of this kind, it is necessary to immerse these coils in oil, but not so with those used for medical purposes. The glass tube insulator must be of the best quality or it will become fractured and the coil is no longer of any use. If we should use larger coils and correspondingly larger sized Leyden jars, we should get a larger current giving greater amplitude, but with less frequency. The electro-motive force is also greater the greater the distance of the spark-gap at *s. s.* This would also increase the amplitude of the oscillations.

SECTION TWO.

The X Ray.

The discovery of the X ray by Conrad Roentgen, late in the year 1895, was one of the crowning events of the nineteenth century. Roentgen's discovery was only an advance from Hertz and Leonard, who had discovered that when a charge of electricity of a very high potential was put through a very high vacuum, it would radiate into the open air space around the vacuum tube certain rays, which would affect a photographic plate, and that it mattered not whether this plate was exposed directly in a dark room or whether it was encased in a pasteboard box. Roentgen, reasoning from this, thought that, as these rays penetrate a pasteboard box, they might possibly penetrate other opaque substances; he tried the human hand and found that the rays penetrated the soft parts as freely almost as they did the box. Roentgen, however, deserves more credit than the above statement apparently gives him, for he discovered the existence of a new ray. Leonard believed that the phenomena he found was only the extension of the cathode ray from the inside of the tube outward, and that it was these rays which penetrated the box and affected the photographic plate. We are, therefore, indebted to Roentgen for the discovery of the new ray.

For the purpose of study we may divide the subject of the X ray into the tube and the cathodic ray; the nature of the X ray; the electric energy necessary to excite the tube and its source; the fluoroscope and its uses; the skiograph and directions for taking the developing plate; the X ray burn and its treatment, and the medical use of the X ray.

The X Ray Tube and the Cathode Stream.—If a vibrating bell be placed within a glass globe, from which the air has not been exhausted, the sound is conducted from the bell to the ear of a person standing within its range, since the air, which is the conductor of sound, conducts its vibrations to the wall of the vessel which, in turn, transmits the vibrations to the external air, and so on into space. If now the air be exhausted with an air-pump, and the globe hermetically sealed, we find that no sound is heard, as the conducting medium has been removed by the production of a vacuum. If a platinum wire be placed within the vaccum and brought to a white heat, by the passage of an electric current through it, and a thermometer be so arranged that the rays of heat are focused upon it, we find, by the rise of the column of mercury, that the vacuum space conducts heat. The fact that an incandescent fibre within a vacuum bulb gives out a brilliant glow is sufficient proof that the vacuum space also conducts light. It is evident, therefore, that while air conducts sound vibrations it does not conduct light or heat.

We need not use an acquired vacuum to illustrate that the conductivity of heat or light does not depend upon air as a conducting medium, for they both travel from the sun to the earth through millions of miles of space which is not filled with air, or, so far as we know, any matter whatever. This conducting medium of light and heat is what we know as ether—sometimes called luminiferous ether, because it transmits vibrations of light; it is also known as universal ether, as it is supposed to exist everywhere, even between the atoms and molecules of solids.

If an incandescent lamp, which, as is well known, has a vacuum, is brought near the prime conductor of a static machine, the fibre within the lamp will be deflected; or, if a lamp which has a continuous current passing through its filament be brought near a magnet, the fibre will again be deflected. The ether, therefore, conducts the influence of electricity and magnetism as well as light and heat.

Here again we have a greater example in nature, for if we watch the daily variations of the magnetic needle for a period of ten and one-half years, we find that these changes are coincident with changes of the spots upon the sun, showing that there is direct transmission of magnetic influence from the sun to the earth.

We find that not only does a vacuum conduct electrical impressions, but the passage of currents of certain great intensities through a vacuum-bulb produces certain radiations of energy, heat, and light. These radiations are known as the anodal and cathodal rays.

If we pass an electric current through a tube which has but a comparatively low vacuum, we plainly see the radiations of certain molecules of the gas remaining within the tube, but as the vacuum is heightened by the withdrawal of more and more of the molecular material within it, the radiant gaseous molecules disappear, and are replaced by certain streams of energy which fluoresce upon the walls of the tube in a beautiful greenish color.

If we place within the vacuum-tube a light vane, delicately adjusted so that the cathode rays strike the paddles, the rapid movement of the vane indicates that there are radiations emanating from the cathode and passing with tremendous velocity in a straight line through the tube, no matter from what point the anode may enter. What all this radiant matter is, has not been fully determined, but is believed to be composed of particles of matter belonging to the residuum of the vacuum and from the electrodes, for when a vacuum is produced to the enormous pressure of one millionth of an atmosphere, there still remains within it thousands, yes, millions of molecules. This radiant matter within the tube was carefully studied by Sir William Crookes, who, in a lecture before the British Association, August 22, 1879, claimed to have discovered a fourth state of matter, thus dividing all matter into solids, liquids, gases and radiant matter. He claimed that this fourth state, or radiant matter, was observable only in very high vacuua. Recently Prof. J. J. Thomp-

son, of Cambridge, England, has by a clever device been able, as he claims, to measure, or weigh as it were, this cathodic stream. He claims that it is composed of particles one thousand times more minute than the atom of hydrogen. The passage of an electric current through this vacuum-tube, in producing the cathodal rays, destroys the residual matter, whatever the nature of that may be, until the vacuum becomes so high that it is impossible to obtain any fluorescence, even with the greatest current intensity.

Just what becomes of these residual molecules is not known. Many believe they are absorbed by the electrodes, while others believe that they are actually forced through the glass by the tremendous energy within. Whatever the cause, the heightening of the vacuum seems to be coincident with a long-

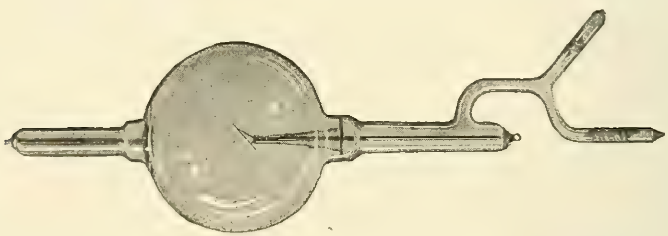


FIG. LVI. X ray tube with offshoot for regulating the vacuum.

continued use of the tube. If a new tube be put under great stress by the passage of a current of enormous intensity, and kept there steadily for any extended period of time, it will get very hot; the vacuum will run up rapidly, and, if the tube is a small one, the vacuum will become so high that the tube will be useless in an hour's time.

The height of the vacuum is all important to the usefulness of the tube. If the vacuum is too low, no X rays are given off. As it rises, it reaches a point of greatest efficiency, and, as it progresses beyond this point, its efficiency gradually lessens.

Nearly all makers of tubes now have some arrangement whereby without reopening the tube the vacuum may be lowered, when it is in danger of becoming so high as to be

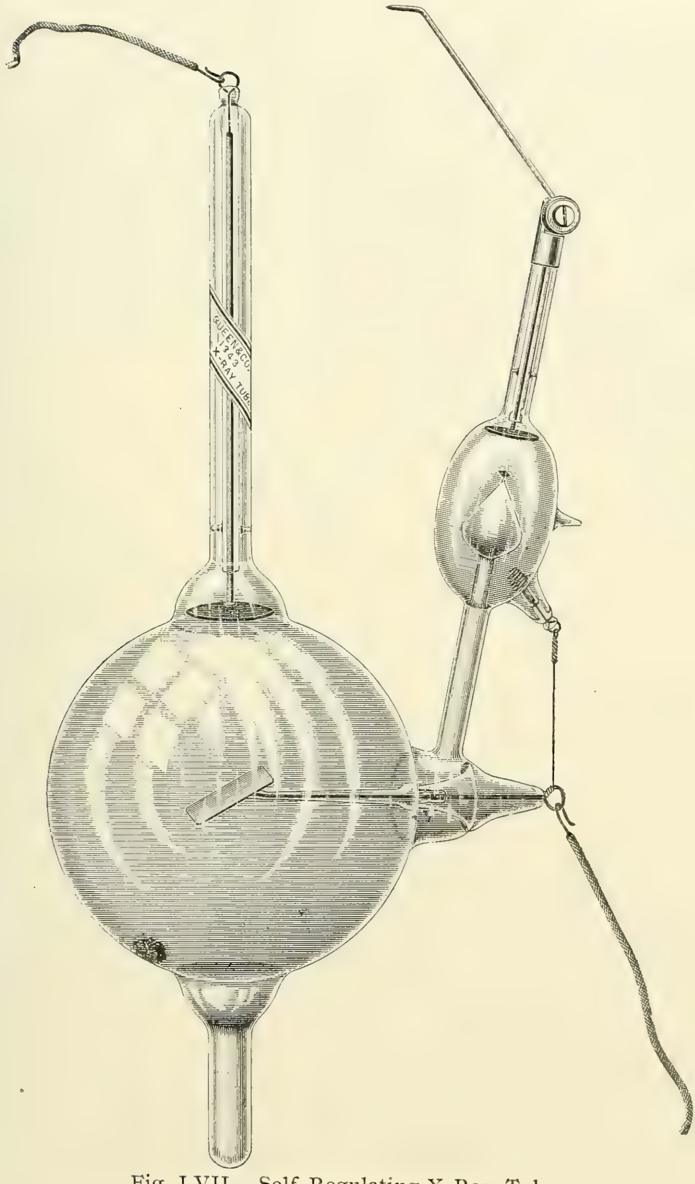


Fig. LVII. Self Regulating X Ray Tube.

useless. This is generally in the form of a third offshoot which contains certain salts so that when the electrode is attached to it gases are formed which lower the vacuum. It has been claimed that the reversal of the tube, that is, placing the anodal connection on the cathode and the cathodal connection on the anode, and passing a current through the tube in this direction, will also lower the vacuum. This may be so with certain tubes, but the operation is certainly very tedious and does not pay for the trouble. Heating a tube with an alcohol lamp will temporally lower the vacuum so that it may produce X ray. This is due to the setting free of the particles of the residual matter which adhere to the walls of the tube.

As particles of matter within the tube are projected with great force against the opposite wall of the bulb, a tremendous friction and more or less rebounding take place. Again those particles charged with electricity in turn communicate a charge to the walls of the bulb. As bodies similarly charged have a repelling effect upon one another, those particles that have already been deposited exert a repelling influence upon those coming toward them, thus setting up an electric stress. All these conditions undoubtedly exert more or less influence in producing the fluorescence. We find that this fluorescent stream of energy is subject to magnetic influence and that the power of the magnet on it, or that its power to withstand the influence of the magnet is in direct proportion to the height of the vacuum; for if Crookes' tube has a projecting bulb containing potash, which, when heated, has the effect of slightly injuring the vacuum, the stream of energy will produce a sharper curve under the influence of the magnet, falling short of where it fell before the heat was applied to the bulb containing the potash.

The Nature of the X Ray.—The first question that arises is this: What are these rays? Are they the cathodal rays extending through the walls of the tube into space? Professor Hertz, of Bonn University, Germany, succeeded in penetrating with

the cathode rays gold leaf which was placed inside the tube, and was sufficiently thick to be opaque to sunlight.

His student, Mr. Leonard, later succeeded in passing these rays through a thin plate of aluminum,—placed as a window in the bulb,—out into space, where they produced a fluorescence. These were positively cathode rays, as they were deflected by a magnet and exhibited all the characteristics of cathode rays. The X rays are not deflected by a magnet, as are the cathode rays, which are also absorbed by light to a much greater extent than are the X rays. Regarding this point,

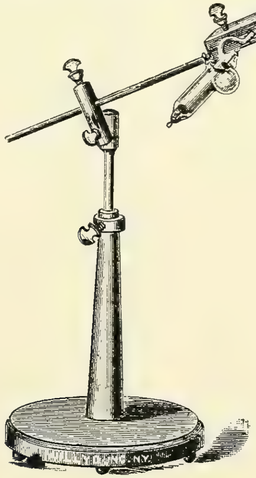


Fig. LVIII. Tube Holder.

the reflection and refraction of the X rays, there was for a time some dispute among scientists, but the most conclusive proof of the accuracy of Prof. Roentgen's statements has been furnished by the experiments. When the sunlight is passed through the spectrum it is divided into several shades; that known as the ultra-violet, consists of rays which produce actinic effect upon a photographic plate. It has been suggested that, as X rays produce this same actinic effect, they are identical with ultra-violet rays, which are also invisible to the naked eye, and that the energy emanating from the tube

assists them in penetrating opaque substances. If this were true, the photographic plates would respond the same to one as to the other. This, however, is not the case. Professor Stein, of Chicago, found that a slow plate responded just as quickly to the Roentgen rays as a very rapid one, and Mr. Edison discovered that a landscape plate, which requires comparatively long exposure to the sunlight, responded to the Roentgen rays more quickly than did the instantaneous plates, which require only a fraction of the time of exposure to sunlight. Dr. W. Y. Cowl, of Berlin, has made the observation that two plates, one of which is one hundred times quicker to ultra-violet rays than the other, act with about equal quickness to X rays. He also claims that the fine granules of the bromide of silver are more sensitive to the X rays than are to the coarse ones, which is just the opposite of the ultra-violet rays. These are not ultra-violet rays, but probably belong a plane far above the latter and the Becquerel ray given off by uranium and other salts during and after exposure to sunlight probably belongs to a plane between the two.

What then is the nature of these rays? Professor Roentgen stated, with much reserve, that they were longitudinal vibrations of the ether, which are vibrations moving longitudinally to the lines of propagation, thus differing from the transverse vibrations of light and heat which move perpendicularly to the line of propagation. If it is true that they are longitudinal vibrations of the ether, this gives us a new conception of the ether itself, for we have generally considered that it was noncompressible, capable only of transmitting transverse vibrations. If, however, we find that it transmits longitudialn vibrations, it must be slightly compressible. Others advance the theory that the rays are lines of magnetic force. Mr. Tesla believes that they are actual particles of matter forced through opaque substances, and their actinic action upon the plate is mechanical; he states that there are certain chemicals which are very sensitive to such mechanical impressions, and suggests that they be utilized to demonstrate the truthfulness of his theory; but, so far as we know, the experiments have

not been successful. However, the recent discoveries by Prof. J. J. Thompson of the minuteness of the particles, the cathode ray being one thousand times more minute than the atom hydrogen, may add new force to this theory.

It has long been known that lightning and large sparks of electric discharges are capable of producing effect upon sensitized photographic plates through certain opaque substances. We now know that this effect is electrolytic. Now, if Mr. Tesla's theory be correct, these particles of matter would naturally contain a certain amount of electrical charge, and would it not be more reasonable to explain their actinic effect on the electrolytic theory, than it would on actual mechanical impulses. The fact that they are capable of conducting electricity is proved by their ability to discharge an electrolyzed plate, as shown by Roentgen's second article on the subject. Various experiments have been made to obtain the Roentgen rays other than by the Crookes tube. It has been claimed that they emanate from an arc light, or from the disruptive discharges from the poles of a static machine, or from bolts of lightning, as has been cited. In carefully comparing the results obtained by the arc light, we find, in the first place, that it is very much weaker in its power of penetration, and that the laws of penetrability are not the same. For example, while color has no effect on the Roentgen rays, so far as we know, with perhaps one exception, ruby, it has on the arc light rays, for two pieces of celluloid of the same thickness and density, one white, the other red, conduct the arc light rays differently. We are sure we are voicing the opinion of ninety-nine out of a hundred scientists, who have experimented on this subject, when we say that the Roentgen rays have been produced only by radiation from an excited Crookes tube.

One of the most interesting points in this connection is the laws governing the penetrability of these rays. It was at first thought that the opacity depended upon the density of the material. This was soon disproved, for substances of similar density varied greatly in opacity. Bone, which was

thought to be very opaque, has been found to be more transparent than lead, for lead bullets within bone are easily detected by their greater opacity. Platinum is the most and aluminum the least opaque of the metals. The opacity of glass seems to depend largely upon the amount of lead it contains. The abdominal and thoracic viscera, as well as the brain,—the kidneys excepted, which seem to be more opaque, are quite transparent. Certainly the transparency of all material depends upon the length of exposure as well as upon the force and quality of the rays. There has been a law evolved governing the conductivity of all bodies to X rays, and that is, that "the penetrability varies inversely as the product of the atomic weights by the specific gravity."

Heat and light vibrations are the same, only differing in the amplitude of their vibrations. Certain substances will conduct heat vibrations and not light, while others will conduct light and not heat. Professor Tyndall, in a lecture delivered in the Senate House before the University of Cambridge, May 16, 1865, described a series of experiments he had instituted to study the conductivity of vapors of various substances to heat and light vibrations. By placing these in a vacuum and allowing the vibrations to pass through them and to concentrate upon one side of a thermo-electric pile, the variation of the galvanometer needle, which was connected with the pile, told the amount of heat that passed through the various vapors. He was thus able to make certain observations, and found that when a substance transmitted a vibration, the amplitude of its molecular vibrations had to correspond to the amplitude of the ether vibration; therefore those substances which conducted heat vibration had a molecular amplitude corresponding to the amplitude of the heat vibrations. We know that the soft parts of the human body have a molecular vibration. It is claimed by many that osmosis is due simply to molecular vibration. In fact, in one of the most recent articles on the subject of osmosis the author claims that the lining, or plastic material inside the cell wall, which is simply the matured protoplasm of the cell, has a certain amount of elastic vibra-

tion, that this vibration gives it the power to conduct substances which have similar vibrations, and that the selective power of different membranes in osmosis depends entirely upon this action.

Now, applying this same law of equality of molecular and ether vibrating amplitude to the penetrability of the X rays of the human body, we naturally conclude that the reason why the body conducts these rays is that its molecular vibrations are equal or similar, at least in amplitude, to the vibrations of the X rays.

If Roentgen's contention that these rays are longitudinal vibrations is true, perhaps it is explained on the ground that the molecular vibrations of the body and other substances traversed by them are longitudinal. This of course is only a theory, but is well worth more careful study.

Not one of the least important questions is, Whence do these rays emanate? Professor Roentgen has stated that they emanate from that part of the tube which fluoresces most; that is, where the cathode rays strike the wall of the bulb, and where the radiant energy of the cathode rays come most directly in contact with the wall of the bulb. Professor Magie, of Princeton College, with a piece of lead, which is very opaque to the rays, with a small opening through it, was able to examine by means of a fluoroscope the surface of the entire tube; he came to the conclusion that the rays were much greater where the glass wall of the tube was thinnest, and, therefore, concluded, in support of Professor Roentgen's theory, that they came from the inside of the tube. The theory has been advanced that they emanate from the cathode electrode, piercing the glass and going on through space; but this is easily disproved by the fact that, when the cathode rays are deflected within the tube, the Roentgen rays emanate from the deflected point. Now, the Roentgen rays are not deflected, and if they emanated from the electrode they would not be deflected, but would pass out from the point directly opposite. Another theory is that, as the vibrating bell within the non-exhausted glass bulb conveys vibrations to the glass,

which in turn conveys the vibrations to the air outside by which they are conducted to the ear of the hearer, so the impaction of the cathodal radiant energy upon the glass produces vibrations which in turn cause vibrations of the ether outside of the tube, this producing the Roentgen rays or vibrations. The thinner the glass the greater would be its vibrations. Therefore, while we can come to no definite conclusions, as to the origin of the Roentgen rays, whether inside or outside the tube, we know that they start from that point of the tube, either inside or out, where the radiant energy of the cathodal stream fluoresces mostly.

The Electric Energy Necessary to Excite the Tube.—As this subject has been treated in detail in the department of electro-physics, we need only call attention to it in this place. The first essential is to have an electric charge or current of sufficient electro-motive force or potential to overcome the resistance of the vacuum tube. The higher the vacuum through which the electric energy can be passed, the better will be the X ray. Therefore those machines which give off the greatest amount of voltage, or, in other words, are capable of generating the longest spark will drive the energy through a higher vacuum and consequently give a better X ray. This may be taken from any source where the potential or voltage is sufficiently high. There are, however, at present but two practical sources, the Ruhmkorff coil and the static machine. Each has its strong advocates. We give preference to the static machine, but must admit that the coil is far more portable. For instance, in a hospital it may be easily moved to a bedside and furthermore, it will generate electricity in all kinds of weather without trouble to maintain it in condition.

If a Ruhmkorff coil is used the two poles are simply attached to the terminals of the electrodes in the tube, and as they are marked positive or negative, there is no confusion. With the static battery a test must be made, as a static machine may change its polarity with every charging, so that one cannot tell, without making a proper test, to which pole to attach to the cathode electrode of the tube. With the static machine

it may also be necessary, if the vacuum is not perfect, to make certain breaks in the circuit, therefore giving a little extra intensity to the discharge. The faster the static machine is run, the greater the amount of electricity given off, and consequently the better the X ray produced.

The Fluoroscope and How to Use It.—Although Professor Roentgen first made use of the fluorescent screen, we believe that the construction of the fluoroscope and the uses to which it is now put, belong independently to Professor Magie, of Princeton College, and Professor Salvioni, of Perugia, Italy. Neither can claim priority, but both may claim originality. The instrument consists of a device or box of any material which will

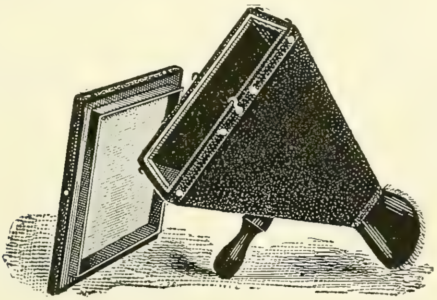


Fig. LIX. Fluoroscope.

shut out the light, across one end of which is placed a paper covered with crystal of tungstate of calcium or platino-barium cyanide. The fluorescent side of the screen is placed inward or toward the open end of the device, the other side being covered with cardboard to protect it. Now, if the eyes of the observer are pressed closely into the open end of the fluoroscope so as to prevent the light from entering,—unless it be in a perfectly dark room, when this is unnecessary,—and an excited Crookes tube be held so that the X rays stream toward the closed end, they penetrate the cardboard and produce on the screen a fluorescence plainly visible to the eye. If, now, a block of wood be brought between the tube and the fluoroscope the rays penetrate it and produce the fluorescent effect

upon the screen. If the hand is substituted for the block of wood, the rays penetrate the flesh, leaving a distinct outline of the bones.

To use the fluoroscope scientifically requires considerable experience. It may often be used to detect congestion and inflammatory deposits in joints by carefully shading down the X ray, or, what will produce a similar effect, by withdrawing away from the tube and comparing it with the healthy fellow joint. A very strong X ray will penetrate a congestion and even an inflammatory deposit so completely that they may not be detected, but as the ray is shaded down, the inflamed tissues or whatever deposits have been thrown out produce a perceptible shadow on the screen. Bones deficient in calcareous deposits are very transparent to X ray. Fractures which have no displacements, the fractured ends remaining *in situ* while showing plainly in a skiograph, may not be detected by a fluoroscope. Foreign bodies may be more accurately located with a fluoroscope than with a single skiograph, as the part in which the foreign body is located may be examined from different angles.

The Skiograph.—The pictures taken by Roentgen rays are not taken by the ordinary process of photography; they are simply shadow pictures and have been variously named shadowgraphs, skiographs, etc. The plate is placed in an ordinary plate holder with the protecting cover remaining on; the Crookes tube is placed from eight to eighteen inches away and focused so that the radiant energy is directly toward the plate. The further the distance, the greater the time of exposure required and the less distinct the picture is liable to be. Dr. W. Y. Cowl, in a paper based on the experiments made at the Physiological Institute of Berlin, and read before the Physiological Society of that city, claimed: "In order to obtain sharp outlines of pictures, the surface on or in the Crookes tube from which the X rays radiated must, with reference to the object to be skiographed, be as small as possible, otherwise we get the same foggy outlines as in the sun shadows on a screen when holding an object before it at a sufficient dis-

tance for the breadth of the sun's surface to come into play." He also asserted that we should not take pictures with the vacuum tube nearer the object than the eye in distinct vision, as otherwise we get a view similar to that when a strong pair of spectacles is used.

According to our experience, these two rules must go together, for if we use a small surface for the X rays to radiate from, and then place the tube near the object to be skiographed, we get a double shadow of all the outer lines. The subject to be photographed is brought between the Crookes tube and the plate, but close to the plate—in fact, it should lie against the plate cover. The flesh is quite transparent,—or perhaps translucent would be a better term,—leaves a dim outline on the plate, while the less translucent bone leaves a deeper shadow within when any part of the body is photographed. The special plates made for X ray work possess one material advantage over the ordinary photograph plates in that they are each enveloped in a sack of paper that is non-actinic and also will not mottle. This paper is especially prepared so that it will not admit the actinic rays of sunlight, but is very readily penetrated by the X rays; thus the plates can be handled in daylight without fear of destroying them. They are made up of two or more coatings, one of which is very much more rapid than the other. If the exposure is somewhat undertimed, the more sensitive layer is quite sure to have been affected sufficiently to give us a picture, and if it is overtimed so that the sensitive layer is destroyed completely, we get a picture from the less sensitive layer.

The time of exposure cannot be given. It must depend upon the part skiographed and the penetrating power of the X ray. Some excellent pictures have been made in a remarkably short time, but this was only under conditions the most favorable. Every operator must learn his tubes and their efficiency and be guided by experience. To give an idea as to the cases in which the X ray may be utilized as a diagnostic agent, we present a few illustrations.

Foreign Bodies.—If the X ray had been discovered twenty

years sooner, President Garfield's life could probably have been saved. Its advent has greatly facilitated the finding of bullets, needles, or other foreign bodies in the tissues. Foreign bodies, of sufficient opacity, lodging in the trachea, œsophagus or stomach, can also be readily detected and promptly removed After ingestion of subnitrate of bismuth, the contents of the stomach may be more readily diagnosed.

Fractures.—At present it seems almost impossible to get along without the X ray for the diagnosis of fractures, especially in doubtful cases. The skiograph is usually preferred to the fluoroscope as being more certain, but the value of the latter in watching the progress of unification cannot be overestimated. It has as yet been impossible to obtain good skiographs of the cranial bones showing obscure fractures not determinable externally but improved technic will, it is hoped, soon overcome this difficulty. Fractures of the vertebræ and their encroachment on the vertebral canal can also be determined by means of the X ray.

Anomalies of the Osseous System.—Congenital malformations such as polydactylism, syndactylism, deformed and contracted pelves, can be accurately diagnosed by the use of the X ray, and operated upon, when necessary.

Diseases of the Osseous System: Pott's Disease, Scoliosis, Osteomalacia, Necrosis.—Many cases of Pott's disease, with but few, if any, symptoms otherwise demonstrable, can be readily diagnosed by the X ray and early treatment invoked, the importance of which is so very vital. Scoliosis can also be easily traced. In cases of orthopedic surgery X ray examination will permit a definite planning of the operation before the knife has disclosed the existing lesion.

Dislocations.—In luxations the X ray diagnosis is valuable, especially when exudations or inflammatory deposits render manipulation difficult. In congenital dislocation of the hip it has been of especial service.

Renal, Ureteral and Vesical Calculi.—When the value of an early detection of calculi is considered, the use of the X ray in this connection, must be admtted as a great advance in diagnosis.

Nephrolithotomy, when performed early, shows a mortality of from two to three per cent., while when employed in later stages, after infection has taken place, it shows a mortality averaging as high as thirty per cent. The diagnosis of even minute calculi can now be made with accuracy and early surgical interference be justified.

Tubercular Deposits.—Tubercular deposits may be clearly revealed by the X ray. Not only is it applicable to the lungs where tubercular deposits may be readily detected even when so minute in size that ordinary methods of physical examination are liable to fail, but similar deposits in the omentum or other abdominal organs may be discovered when other diagnostic procedures entirely fail.

Biliary Calculi.—Beck, after many failures, succeeded in locating biliary calculi by means of X ray photographs. A test is first made by exposures for five, and then for ten minutes, the most powerful focus tubes being necessary; then by comparison, the best time for exposure can be determined. The patient should lie on the abdomen with a pillow under the symphysis as well as under the clavicle, the body being turned slightly to the right, with the left side raised. The rays should not penetrate the abdomen vertically but from side to side and should form an angle of about 45 degrees with the plate.

A skiograph taken by this method with exposure of six minutes, showed two large calculi in the gall bladder, one in the cystic duct and three in the liver, the elliptic shape, size and diameter being well marked.

Arthritis Deformans and Gout.—Deposits can now be readily differentiated by means of the X ray and proper treatment instituted.

Position, Shape and Size of Organs.—With improved technic the position, shape and size of the heart is more readily determined by means of the X ray and examinations of the liver, spleen, stomach and kidneys are no longer subject to doubt. Movable kidney may, in suitable subjects, also be determined by comparison.

Aneurism of the Aorta no longer presents any difficulty of diagnosis and can be distinguished even by the inexperienced.

Developing Plates.—In the development of plates exposed to the X rays, be they the ordinary or those specially made for the purpose, the treatment is the same as if exposed to any other artificial light, to moonlight or to daylight.

It is well to start out with the understanding that the developed plate itself is a positive and the true picture, and that a print from this plate is a negative, so that to obtain a positive by print the proper method is to make a negative by contact, from which as many prints may be made as desired, these being the true pictures or shadowgraphs of the subject.

There are many developers, and without criticism it is fair to presume that each plate maker gives the formula best adapted to his plates. Operators, however, may have their pet formulas and may get better results from their own developers than from the formulas that come with the plates.

The beginner in the developing of X ray plates should feel that each exposure is an unknown quantity and begin cautiously with a weak and slow developer until he ascertains as to the timing of the exposure when he can regulate the further development as required. How far to carry development can be judged only by trial, for some plates thin out very much more than others in the fixing bath; this fact being known these plates should of course be developed to greater intensity. It is better to give full time exposure, for it is much easier to overcome over-exposure than to correct much under exposure.

The common developers now in use are pyrogallol, hydrochinon, eikonogen, metol, etc. To these are added sulphite of sodium which prevents oxydation, and an alkali such as carbonate of sodium and potassium and water. Certain quantities of these ingredients with water make a normal developer for the various kinds of plates, so much developer, so much sulphite, so much alkali, so much water. Some compound the mixture in one solution, others mix the alkali with water, and the developer with the sulphite and water, mixing

such proportions of each when needed for use and in such proportions as seem desirable for the occasion.

Each of the developers above enumerated will develop a plate in its peculiar way. Pyrogallol, or pyro, as it is called, is a great favorite among the elder photographers, it being claimed that with its proper use it will do all that the others can do singly or conjointly. Its liability to stain, however, is very much against it. There are many formulæ, such as hydrochinon and metol, or hydrochinon and eikonogen. Hydrochinon is slow but persistent, gives great density and contrast, and is not liable to fog. Eikonogen and metol are more energetic and are much more liable to fog, giving, perhaps, finer graduation, and hence detail, so that a proper mixture makes the happy medium. Hydrochinon, however, has many firm friends who claim that being properly compounded with its alkali, sulphite and water, it will do all that can be done with any developer. We present herewith a few formulæ which have given great satisfaction.

No. 1.

Water,	6 ounces.
Sulphite of soda cryst.,	60 grains.
Eikonogen,	10 grains.
Hydrochinon,	5 grains.
Carbonate of soda,	60 grains.

No 2.

Water,	1 ounce.
Sulphite of soda cryst.,	30 grains.
Carbonate of soda,	30 grains.
Hydrochinon,	6 grains.

No. 3.

Water,	1 ounce.
Sulphite of soda,	20 grains.
Carbonate of potassium,	15 grains.
Hydrochinon,	5 grains.

Formulæ Nos. 2 and 3 may be diluted with as much again water as the subject may require. All of these may be used over and over again, remembering that they work slower and more intense each time. An addition, therefore, of a little new developer with that already used, is frequently of advantage.

Plate makers also give formulæ for a fixing bath and no doubt any of them will do with any kind of plate. A bath of about 1 pint of hyposulphite of soda to four ounces of water makes a bath which will do practically all that is necessary in cold weather, though the addition of a little sulphite of soda may be of advantage, keeping the bath clear. Placing the plate in a solution of alum—chrome is best—and water before or after fixing is also of advantage sometimes, as it hardens the film. After developing, rinse the plate in water, and place it in the fixing bath and keeping it there five minutes after all traces of white have disappeared. Then wash it in eight or ten changes of water, say five minutes each, place it in a rack and let it dry. The drying may be hastened by placing the plate before a hot air register, but do not attempt to do this with other heat.

A plate properly developed should not need strengthening, but if such should happen to be required the following formulæ will be found satisfactory:

Strengthening Solution.

I.

Water, ...	10 ounces.
Bichloride of mercury, ...	¼ ounce.
Chloride of ammonia, ...	¼ ounce.

X Ray Burns.—The subject of X ray burns is not yet well understood and pages might be written upon the different theories put forth regarding it. One thing, however, is certain. Whatever the nature of the burn may be, whether the destruction of the blood-vessels, of the nerve filaments or the tissues in mass or not, there is a great interference with the nutrition of the parts. It matters not whether the X ray is a

strong penetrating one or not, an X ray burn will come from a very low vacuum tube which is giving off scarcely any X ray. Neither is it always due to long exposure. In one case we have recently seen, a hand was severely burned which was not exposed for more than half a minute in testing a fluoroscope, when the same ray was afterwards used for ten or fifteen minutes upon the shoulder of another person without producing any burns whatever. Whether the burning is due to the driving in of certain impurities on the surface of the body is a mooted question, but there seem to be some constitutions or certain individuals who are more susceptible to X ray burns than others. Two things, however, generally have a distinct bearing upon X ray burns; one is the nearness of the tube to the part examined, and the other is the length of time of the exposure. Some claim that if a tube is placed more than twelve inches away from the part examined the person is safe, but there are scores of cases on record which have been burned when the tube was more than twelve inches away. The length of time of exposure, as has been stated, is not always a safe criterion, but the longer the exposure the more liability there is to burns.

The treatment of X ray burns has been perplexing. Skin grafting has not proved very successful probably owing to the low state of nutrition. The one topical application which has proved to be more curative and stimulating is the stearate of zinc. It is claimed that if the part affected be immersed in a faradic bath composed of a weak saline solution as soon as the burn is first noticed, it will retard the destructive effect. This, however, is doubtful but the relief of the symptoms is often quite marked.

In those cases where there is left an indolent, unhealthy base, a galvanic bath is at times effectual. The bath should be composed of a weak saline solution and the affected part should be placed between the electrodes. Here we get two distinct effects. One is the stimulating effect of the electric current which will depend upon the amount of current passed and the strength of the saline solution. Everything conducts elec-

tricity according to its conductive capacity or the resistance it has. The stronger the saline solution, the better conductor it is and consequently the limb having a comparative larger resistance, takes but little of the current. Still it takes some and so thoroughly is this distributed to the unhealthy base,—as the skin furnishes a large part of the resistance of the body,—that where it is denuded of the skin as in this case, the current penetrates most. The other effect is chemical. A hypochloride is formed and the great affinity of the chlorine for hydrogen attracts the latter to it, thereby setting free oxygen, which acts powerfully upon the unhealthy base.

The Germicidal Effects of the X Ray.—No doubt the X ray possesses a germicidal power as is evidenced by its effects on lupus and epithelioma. This will be considered in connection with the diseases in which it has been thus found useful. As will be there seen, however, very little is known regarding its value. It may develop more in its therapeutic action as our experience with it grows, but it is now used chiefly as a diagnostic agent.

SECTION THREE.

Motor Points.

To understand the principles of electro-diagnosis is one thing and to be able to put them into practice is quite another. Here the acquirement of a technic, both intellectual and manual, is necessary. The one great obstacle to the beginner is the motor points. He studies his chart and compares it

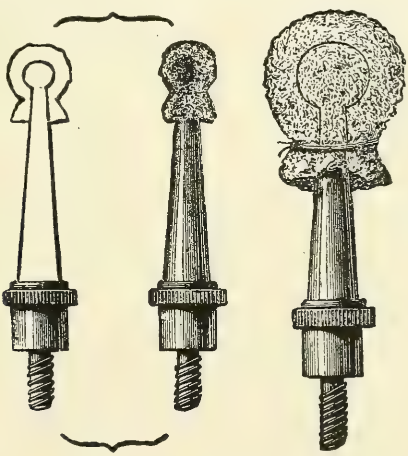


FIG. LX.

with the limb he has before him, but is almost sure to be disappointed. Every one has gone through this experience, and has learned through many failures that a little pressure here or a little pressure there is needed to produce the required muscular contraction. The profession is indebted to Dr. Toby Cohn,* Berlin, for having worked out this problem, and for

*Electro-Diagnostik und Electro-therapie, Berlin, Germany, 1899.

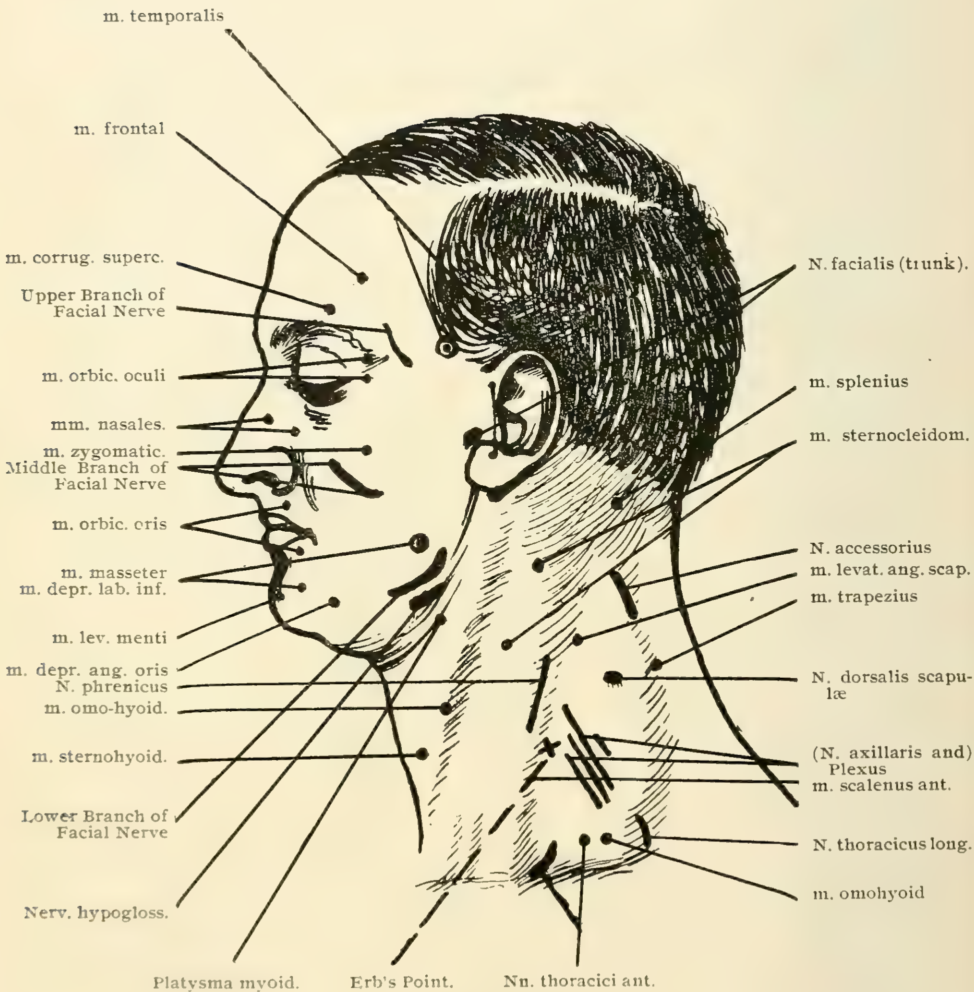

m. temporalis
m. frontal
m. corrug. superc.
Upper Branch of Facial Nerve
m. orbic. oculi
mm. nasales.
m. zygomatic.
Middle Branch of Facial Nerve
m. orbic. oris
m. masseter
m. depr. lab. inf.
m. lev. menti
m. depr. ang. oris
N. phrenicus
m. omo-hyoid.
m. sternohyoid.
Lower Branch of Facial Nerve
Nerv. hypogloss.
Platysma myoid.
Erb's Point.
Nn. thoracici ant.
N. facialis (trunk).
m. splenius
m. sternocleidom.
N. accessorius
m. levat. ang. scap.
m. trapezius
N. dorsalis scapulæ
(N. axillaris and) Plexus
m. scalenus ant.
N. thoracicus long.
m. omohyoid

FIG. LXI.

King, Electricity in Medicine and Surgery.

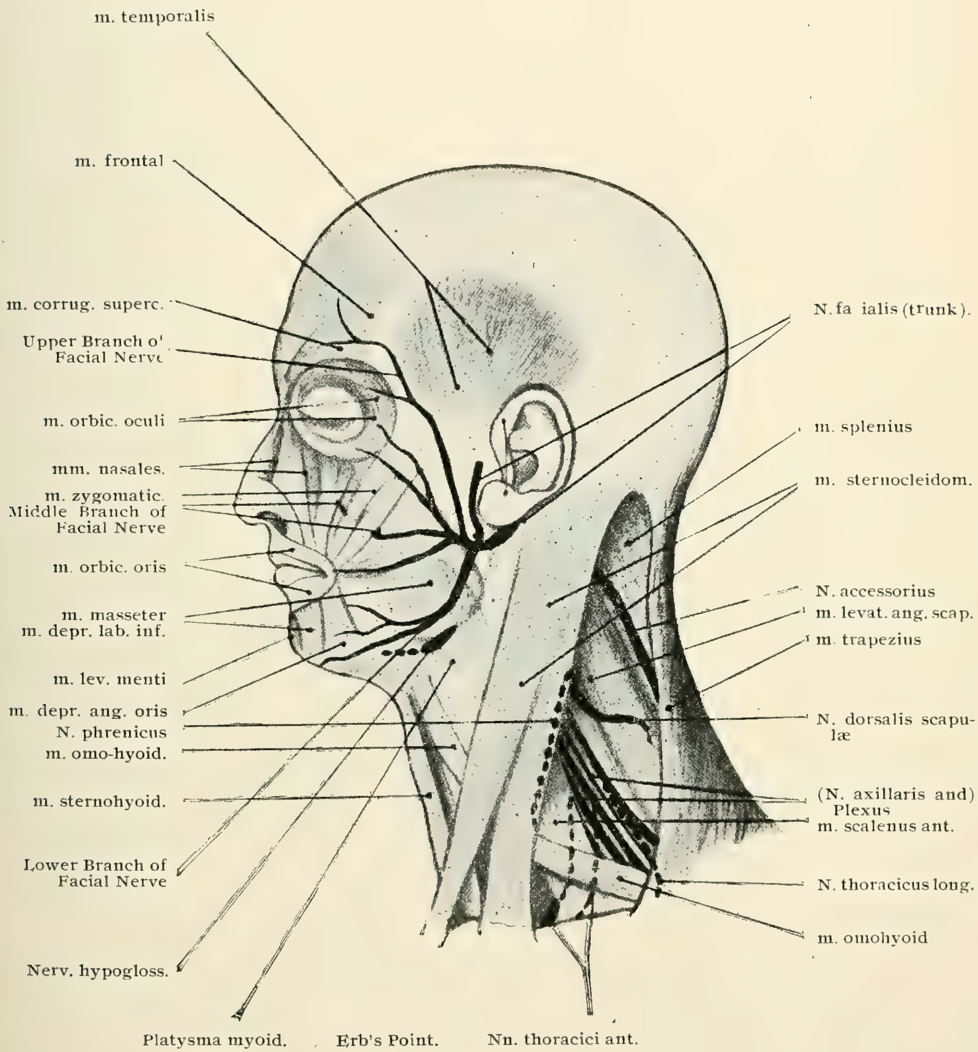


PLATE I.

[To face page 118, Part One.]

giving carefully prepared rules and directions for reaching these points. Of such importance is the subject, that we have concluded to devote a section of this volume to the study of the motor points; the material of this section is largely taken from Cohn's work, including the illustrations, which in some cases have been greatly modified.

Nerve Electrodes.—In irritating nerves the electrodes are of not a little importance. The inactive electrode should be larger so as to decrease the resistance and, also, so as to cause but little pain. The active electrode must necessarily vary in size for there are certain points to isolate, for which a very small electrode must be employed; while in others a larger electrode will not only be more certain in producing the required irritation but also will cause less pain. Various sized and shaped

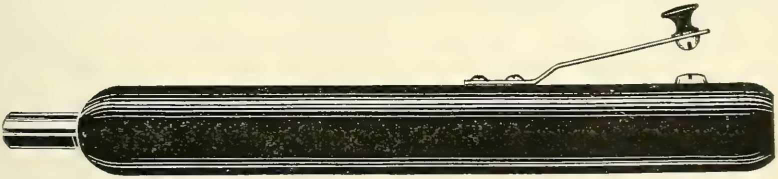


FIG. LXII. Interrupting Handle for Irritating Nerves.

electrodes have been recommended by different electro-therapeutists but those recommended by Erb and known as Erb's nerve electrodes (Fig. LX), are the best. So well have these electrodes become known that most instrument makers keep them in stock. They are oval shaped, varying in size from about a number twelve French scale to a number thirty-five.

The Nerves and Muscles of the Face.—In all examinations of the face it is advisable to hold one hand against the side of the face not being investigated so as to prevent movement of the head. In testing the muscles of the mouth, the latter should be slightly opened.

The trunk of the *facial nerve* can usually be irritated at two places: (1) in the angle between the mastoid process and the descending ramus of the lower jaw. The electrode should be pressed upward and anteriorly into the angle, being inserted beneath the lobule of the ear. Action causes contraction of

all the muscles of the face supplied by the facial nerve; the muscles supplied by the upper branch (occipito-frontalis and corrugator supercilii) frequently contract faintly or not at all. The nerve is moderately irritated.

(2) At the tragus of the ear. At this location, action of the second and third branches only are frequently elicited. This point is not constant.

The three branches of the facial nerve can be irritated separately. They are situated in parallel lines beneath one another: the middle branch at the tubercle of the zygomatic process or slightly beneath it; the upper branch just above it where a given line would cross the superciliary arch; the lower branch beneath these where a given line would mark the horizontal ramus of the lower jaw.

Irritation of the upper branch causes contraction of the occipito-frontalis and corrugator supercilii with wrinkling of the forehead and eyebrows.

Irritation of the middle branch causes contraction of the orbicularis oculi, the zygomatic muscles, the muscles of the nose, the levator labii superioris and orbicularis oris. Action: causes closing of the eyes, movements of laughter, turning up of the nose, wrinkling of the upper lip or angles of the mouth.

Irritation of the lower branch causes contraction of the levator menti, depressor labii inferioris, depressor anguli oris; also the lower half of the orbicularis oris. Action: causes raising of the chin, turning over of the lower lip and distortion of the angle of the mouth downward and outward.

Of the various muscles of the face which can be irritated these may be mentioned:

(1) Frontal portion of *occipito-frontalis;* irritated mostly at the upper outer angle of the respective side of the forehead near the border of the hair. Causes cross-wrinkling of the forehead, raising of the eyebrows. The faradic irritation is in this location quite painful, hence short closure is essential. In galvanic irritation at this location, as well as at the other facial muscles, vertigo, flashes of light, etc., are produced.

(2) *Corrugator supercilii:* usually somewhat internal to the

motor point of the upper branch of the facial nerve. Causes horizontal wrinkling of the region between the eyebrows. This point is differentiated from the neighboring motor point as the latter also has the additional action of the frontalis muscle and is also much more irritable.

(3) *Orbicularis oculi;* at the outer angle of the orbit. Causes moving of the two lids towards one another. In pathological cases (R. D.) the point most readily irritated is found on the upper or lower lid.

(4) *Nasal muscles;* difficult to irritate (and practically of no value); irritable in a medium line from the inner canthus near the root of the nose. Causes turning up of the nose and slight raising of the upper lip.

(5) *Zygomaticus minor and major:* Somewhat below and lateral to the foregoing point. Causes movements of laughter.

(6) *Orbicularis oris:* Can be irritated in two parts: (*a*) the upper portion about the width of a finger above red of the lips somewhat internal to the outer angle of the mouth. Causes wrinkling and pointing of the upper lip. (*b*) lower portion, quite close to the red of the lips and somewhat more median to the upper point. Causes wrinkling and pointing of the lower lip.

(7) *Levator menti:* On the chin near the border of the lower jaw and quite close to the median line. Causes raising of the chin and wrinkling of same. (The beginner is, at this location, apt to irritate the symmetrical muscle of the other side.)

(8) *Depressor labii inferioris:* Somewhat lateral and above of the foregoing point. Causes turning over of the lower lip externally. (Frequently difficult to separate from the foregoing or following muscle.)

(9) *Depressor anguli oris:* Usually close to the lower border of the horizontal ramus somewhat external and below the former. Causes drawing of the lower lip downward and outward. This point is located close to the motor point of the third branch of the facial nerve. The action of the latter can be differentiated from the muscle, as the nerve is more irritable

and its irritation also contracts the levator menti, producing raising and wrinkling of the chin. In pathological cases the point of this muscle is frequently further up, near the lip. On the face two more muscles are found which are not supplied by the facial but by the third branch of the trigeminus; they are the masseter and temporal muscles. The masseter muscle is irritated in the center between the zygomatic arch and the horizontal ramus, about 1½–2 breadths of a finger, lateral to the lobule of the ear. The temporal muscle is irritated near the middle of the temporal groove about equidistant from the border of the zygomatic arch and the border of the hair. The two last muscles cause movements of mastication and striking together of the teeth; both are only influenced by fairly strong currents.

In facial paralysis with absence of irritability of this nerve, the action of these muscles is clearly noted after irritation of the motor point of the facial nerve; the beginner must be careful not to confound this with facial contraction.

The Nerves and Muscles of the Neck.—On account of the different development of the region of the neck (and especially of the fossa supraclavicularis) in various persons, the location of the most irritable points will be changeable, according to individual contour. In many cases we will have to be content with finding the main nerve points. The more expert the operator, the more frequently are positive results obtained.

The *accessory nerve* is irritated in the posterior triangle averaging about two widths of the finger below the upper angle, near the upper portion of the trapezius muscle. It is very easily irritated. Causes contraction of the sterno-cleido mastoid and of the trapezius; the latter also receives, by the way, filaments from the cervical plexus. The head is drawn backward, the chin is raised and turned to the other side.

The *hypoglossus nerve* is irritable close above the greater cornu of the hyoid bone. A small electrode must be deeply applied, producing moving, wrinkling and bending of the tongue. The muscles of the tongue are readily irritated by direct application of the current.

The *brachial plexus* is irritated in the whole of the lower inner third of the supraclavicular fossa and also laterally of the same, parts of the plexus are readily reached. Causes depending on place of application; movement of the whole upper extremity, bending of the hand and of the fingers, lifting of the arm from the thorax, etc.

The supraclavicular point of Erb is irritable at a point in the cervical plexus usually slightly more than the breadth of a thumb above the upper border of the clavicle and slightly lateral to the sterno-cleido-mastoid. The point changes its position frequently, depending on the shape of supraclavicular fossa. From this point are obtained: contraction of the deltoid muscle, the biceps, brachialis anticus and supinator longus with jerky lifting away of the arm from the thorax and vigorous bending of the elbow into pronation.

Anterior thoracic nerves: The ball electrode is pressed deeply behind the clavicle at its superior border with the arm hanging down, using strong currents; or at the upper border of the pectoralis major. Causes contraction of the pectoralis muscles; adduction of the arm to the thorax.

The *posterior thoracic* nerve (long thoracic, external respiratory nerve of Bell) is frequently non-irritable at the neck; if so, irritation is accomplished in the external angle of the posterior triangle of the neck by pressing deeply with a ball electrode. Causes contraction of the serratus magnus; the scapula is moved anterior externally or the separate serrations of the serratus are seen propelled.

The *circumflex nerve* is irritated somewhat to the side and above the former, near the external angle of the triangle; also irritated in certain persons in the axilla. Causes contraction of the deltoid; lifting of the arm from the thorax.

The *dorsalis scapulæ nerve* is frequently, but not readily, irritated somewhat internal to the former. Causes contraction of the rhomboid muscles and of the levator scapulæ, with raising of the scapula of same and turning upward and inward.

The *phrenic nerve* is rarely irritated for diagnostic purposes; for therapeutic purposes (asphyxia) it should be irritated al-

ternately on either side—the most irritable point is located behind (or under) the sterno-cleido-mastoid, at the upper third; it is also irritated further down. The electrode (not too small in size) must be practically shoved under the muscle and the muscle raised. When the point is not correctly found, the electrode is often thrown out by the contraction of the sterno-cleido-mastoid or instead of the desired effect, twitchings, etc., are noted. Causes contraction of the diaphragm; anterior curving of the epigastrium and marked entrance of air through the glottis into the trachea with an audible, "hiccoughy" noise.

Of the muscles of the neck the following may be mentioned:

The *sterno-cleido-mastoid* is irritated most easily at the center of the muscle. Causes expulsion of the muscle from the contour of the neck, turning of the head to the other side with bending of the concha of the ear forward.

The *omo-hyoid:* Its irritation is of no importance. Causes propulsion all along its length.

The *levator anguli scapulæ* is frequently irritated close under the circumflex point; raises the shoulder with slight turning of the head to the irritated side.

The *splenius capitis et colli* is irritated close under the mastoid process. Turns the head to the irritated side.

The *platysma myoides* is irritated in the anterior triangle of the neck in its upper portion somewhat below the level of the hyoid bone. Causes tension of the epidermis of the neck and slight pulling down of the angle of the mouth.

The *external laryngeal*, a branch of the superior laryngeal, supplies the crico-thyroid muscle. This branch, unlike the internal, does not penetrate the thyro-hyoid membrane, but runs down the outer and posterior edge of the thyroid cartilage to a point midway between its extremities, where it divides; one part supplying the thyroid body, the other the crico-thyroid muscle. The motor point of this nerve is just at its division and is easily reached by placing the electrode along the posterior border of the thyroid cartilage, about an

eighth of an inch above the line drawn directly backward from the pomum Adami.

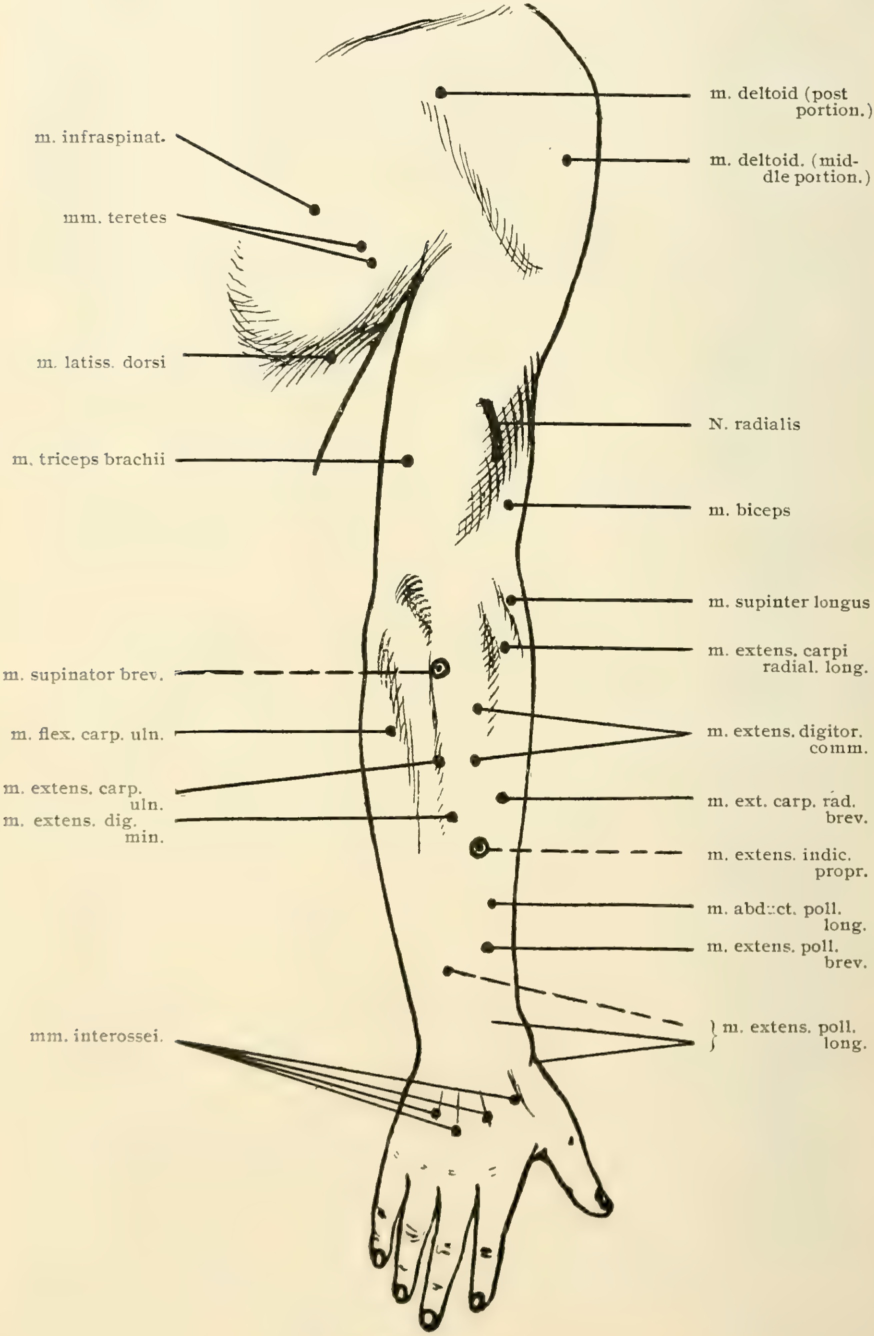
The *inferior laryngeal* nerve which supplies the arytenoideus and crico-arytenoidei lateralis passes under the lower border of the inferior constrictor muscle just in front of the carotid, and into the larynx at the point of articulation of the anterior cornu of the thyroid-cartilage with the crycoid. It is just as it dips under the inferior constrictor muscle that it is most easily reached. The operator should first locate the point by carrying his finger back along the side of the cricoid cartilage until he reaches the point of articulation with the inferior cornu of the thyroid cartilage. Just back of this point the distinct beats of the carotid artery will be felt. The electrode should be firmly pressed between these two points and the nerve will at once respond. The small sized Erb electrode can be used for this purpose, but one made of the same diameter but more oval in shape is better.

The muscles of the palate and tongue are easily irritated with appropriate electrodes.

It is worthy of mention that by stroking the region of the side of the larynx from above downward with the cathode of the galvanic current (3-6 milliamperes) hiccough may be relieved. Faradism does not produce this action.

THE NERVES AND MUSCLES OF THE UPPER EXTREMITY.—To examine the muscles and nerves of the arm, the arm slightly bent at the elbow is placed upon a support, preferably on the unemployed hand of the operator. It should not, however, be encompassed and the thumb must not interfere with the action of the muscles—the hand being used only as a resting place.

The *radial nerve* is irritated at the outer side of the arm in the center between the insertion of the deltoid muscle and the external condyle of the humerus. At this point or slightly above or below it the electrode is firmly placed between the biceps and triceps with the arm resting on the operator's hand and the elbow somewhat bent. Care must be taken not to irritate the biceps as its contractions will cloud the other



m. deltoid (post portion.)
m. infraspinat.
m. deltoid. (middle portion.)
mm. teretes
m. latiss. dorsi
N. radialis
m. triceps brachii
m. biceps
m. supinter longus
m. extens. carpi radial. long.
m. supinator brev.
m. flex. carp. uln.
m. extens. digitor. comm.
m. extens. carp. uln.
m. ext. carp. rad. brev.
m. extens. dig. min.
m. extens. indic. propr.
m. abduct. poll. long.
m. extens. poll. brev.
mm. interossei.
m. extens. poll. long.

FIG. LXIII.

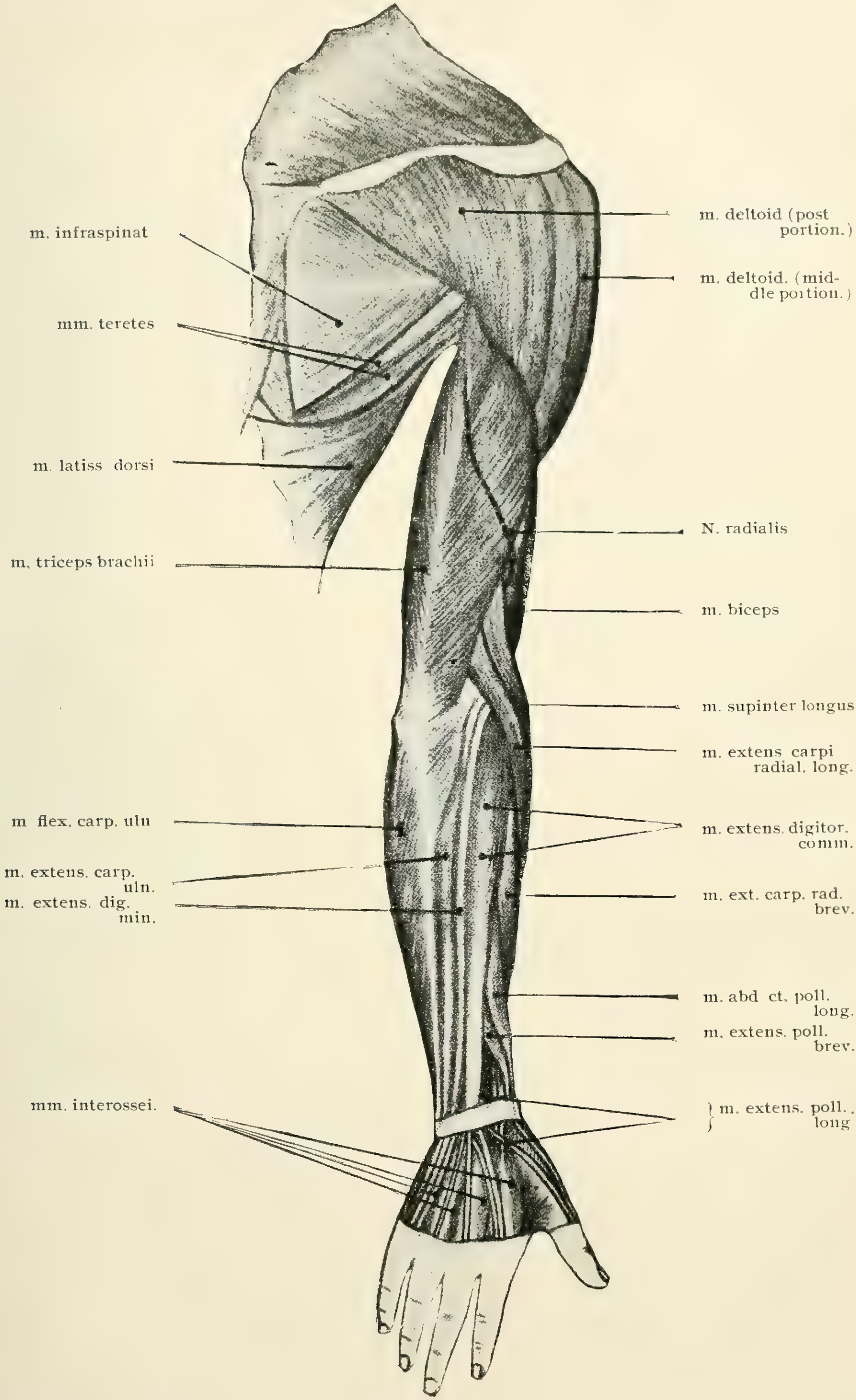


PLATE II.

[To face page 126, Part One.]

effects. Causes contractions of the extensor muscles of the hand and fingers (the supinator longus and brevis being not quite regular); also extension of the hand and fingers with supination and bending of the elbow. It is worthy of note that the radial nerve is much more easily irritated with the cathode of the galvanic as well as the faradic (opening) current than with the anode.

With the faradic current, especially when fairly strong, the twitching in the radial region is not continuous during the whole of the closure of the current; it is usually only visible for a short time. This is explained from the fact that the point of irritation of the nerve is close to the point of the triceps muscle and when the latter contracts, it throws out the electrode thus removing it from the radial nerve point. The radial nerve is also irritated in the uppermost portion of the posterior part of the axilla. In testing this important and practical nerve point it is essential to beware of interfering with the action of the electric current through the operator's hand, an error quite common with beginners.

The *ulner nerve:* (1) This is irritated at the fossa ulnaris internal from the olecranon process. The arm of the patient on irritation of this nerve is raised at the shoulder with elbow bent slightly and the hand and its palm hanging downward. Causes contraction of the interosseus muscles, of the adductor pollicis, flexor carpi ulnaris and part of the flexor profundus digitorum. The wrist joint is inclined toward the ulnar side, the two or three last fingers are flexed, the index finger is adducted to the middle finger and the thumb to the index finger; at the same time the thumb is extended and usually also the two last phalanges of the index finger. The most typical position from irritation of the ulnar nerve is notably the position of the thumb and index fingers and these can be quite readily differentiated from other irritations.

(2) The lower part of the ulnar nerve is irritated directly above the wrist at its ulnar side. Here the adductor-pollicis and interossei are only affected with adduction of all fingers to

one another, flexing of the first and extension of the last phalanges.

The *musculo-cutaneous* nerve: The trunk of this nerve is sometimes irritated at the uppermost part of the arm, internal to the inner border of the deltoid muscle; the intra-muscular branch, supplying the biceps, is more readily affected.

The median nerve is irritated in the middle of the bend of the elbow, usually external and adjoining the tendon of the biceps. The nerve can also be irritated at the whole sulcus bicipitalis internus, but its action is often clouded as the ulnar and musculo-cutaneous are also affected. The effect of the irritation produces contraction of all the flexors of the hand and fingers, the pronators and the muscles of the thenar eminence, causing vigorous bending of the hand and fingers, complete pronation of the fore-arm and opposition of the thumb. The electrode must be lightly applied and the arm should be bent at the elbow with the palms looking upward. The vigorous pronation caused by the irritation of the point of the nerve often prevents recognition of the contraction of the muscles of the ball of the thumb; same can, however, be seen when pronation is prevented by opposing same.

The *median nerve* is also irritated along the whole course of the flexor surface of the forearm, along the center—most readily directly over the middle of the wrist between the prominent tendons of the flexor carpi radialis and the palmaris longus or at the ulnar border of the tendon of the latter muscle. The muscles of the ball of the thumb, especially the opponens pollicis and the outer portion of the flexor brevis pollicis and abductor pollicis are readily irritated on the ball near the base of the hand which is relaxed for the purpose. Causes opposition of the thumb, and flexing of the metacarpal bone of the thumb.

The *abductor brevis pollicis* muscle is irritated near the radial border of the ball of the thumb nearer the wrist than the metacarpo-phalangeal joint.

The *adductor pollicis* muscle may be jointly irritated with the first interosseus muscle or frequently in the palm of the

hand toward the ulnar side of the ball of the thumb about over the middle of the metacarpal bone of the index finger. These two muscles cause, combined with the inner portion of the flexor brevis pollicis, flexing of the first and extension of the second phalanx of the thumb with abduction and adduction of same.

The *interossei and lumbricales* muscles are examined together. They are very important muscles. The most irritable points are located on the dorsal side of the hand, proximal to some extent, in the interosseus spaces. The electrode need not be pressed hard to get reaction, but it is essential to see that the muscles are relaxed. The hand to be examined should have a support, (preferably the hand of the physician) the palm looking downward and the fingers hanging downward in a loose, relaxed manner, somewhat apart.

Irritation of the interosseus produces approximation of the two fingers between which it is located, also flexion of the first phalanx and extension of the two last phalanges. In paralysis of the interossei (ulnar paralysis) the first phalanx is hyperextended and the last phalanges are flexed (instead of extended) producing the "claw-like" hand.

The muscles of the ball of the small finger (opponens, flexor and abductor digiti minimi) are irritated at the base of the hypothenar eminence. They produce actions as indicated by their names and cannot always be isolated.

In order to irritate the muscles of the extensor side of the forearm, the elbow of the patient is bent and the hand placed in slight pronation.

The *supinator longus* may then be irritated at the radial aspect of the extensor part leading to the flexor portion of the brachialis anticus, at about the summit of the bulk of the muscle. This bulk of the muscle is readily seen when the patient is directed to flex the elbow half way between pronation and supination and this flexion is then opposed. The action of the electrical irritation is to flex the elbow joint and cause slight pronation of the hand. In order to see pronation best, the hand of the patient should be slightly supinated.

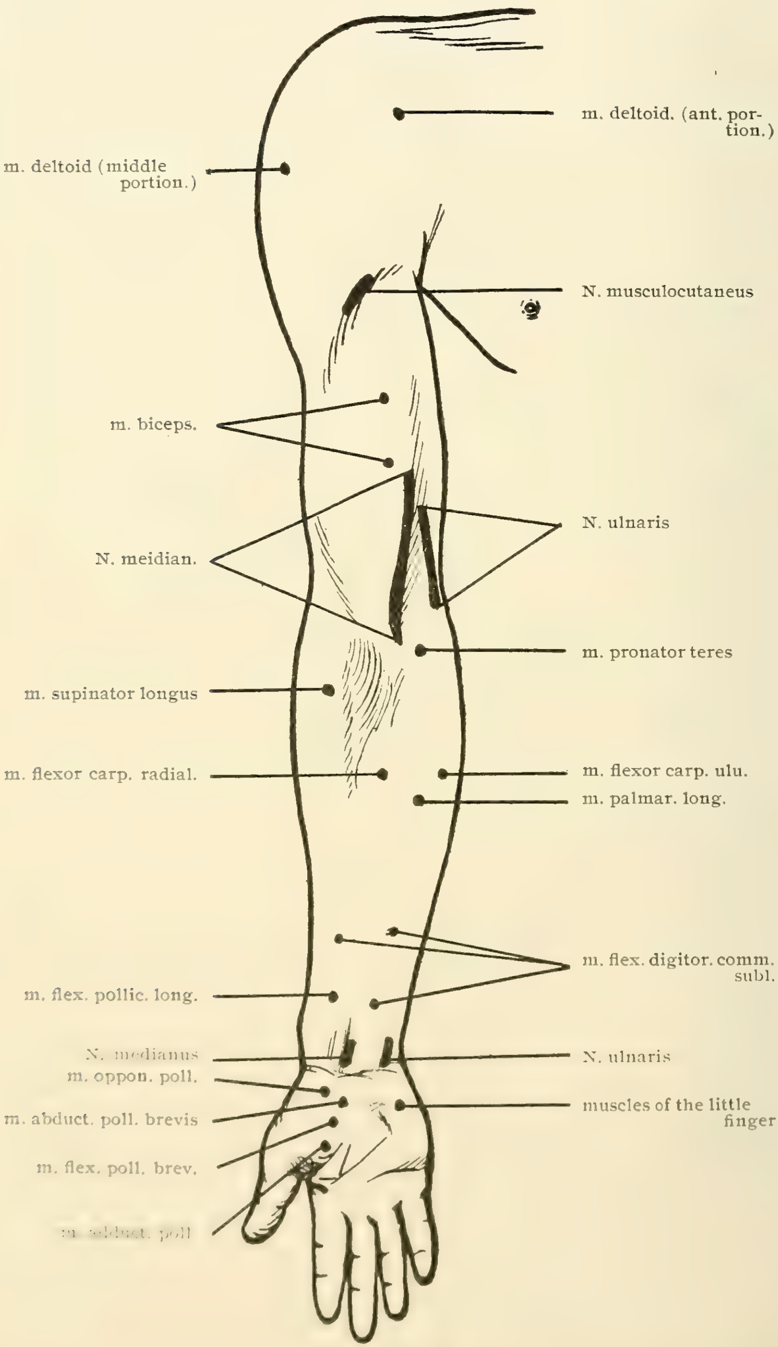

m. deltoid. (ant. portion.)
m. deltoid (middle portion.)
N. musculocutaneus
m. biceps.
N. ulnaris
N. meidian.
m. pronator teres
m. supinator longus
m. flexor carp. radial.
m. flexor carp. ulu.
m. palmar. long.
m. flex. digitor. comm. subl.
m. flex. pollic. long.
N. medianus
N. ulnaris
m. oppon. poll.
muscles of the little finger
m. abduct. poll. brevis
m. flex. poll. brev.
m. adduct. poll

FIG. LXIV.

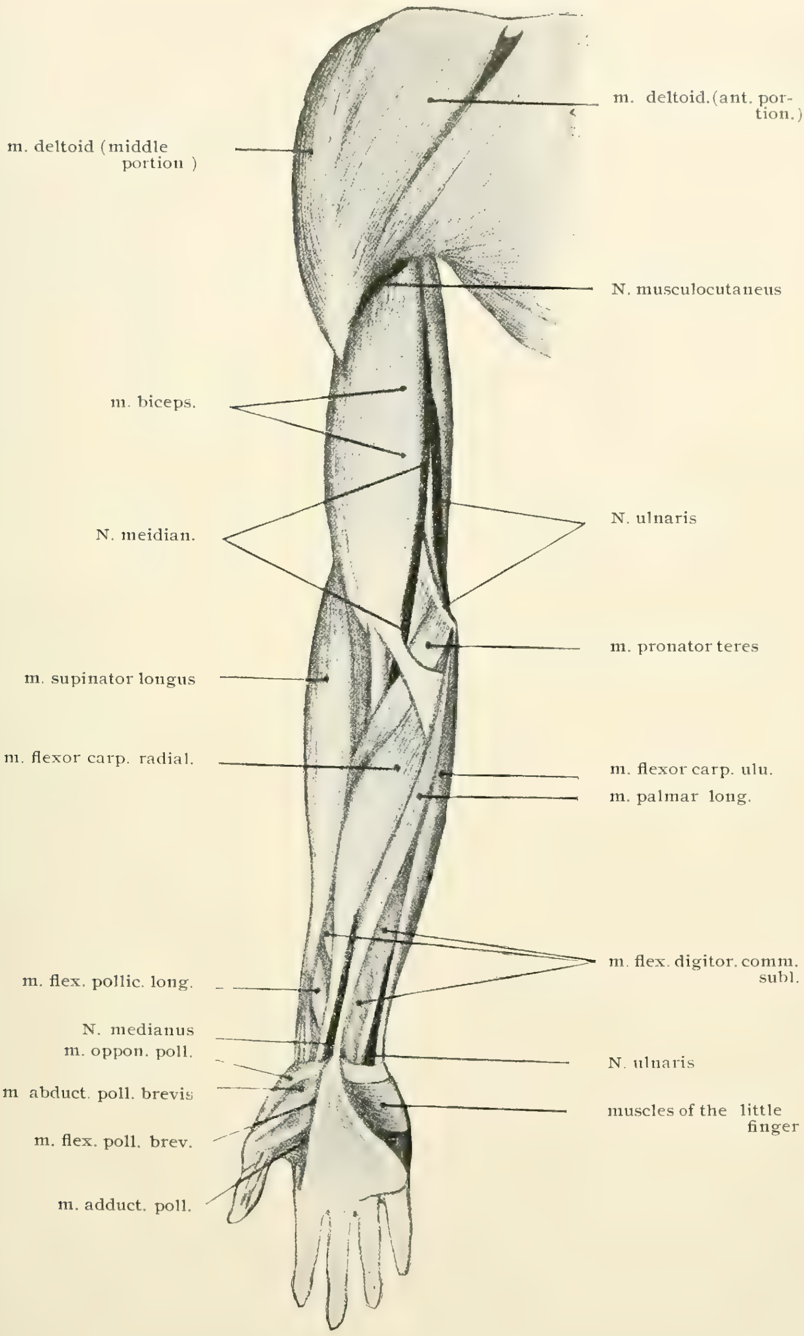


PLATE III.

[To face page 130, Part One.]

The *supinator brevis* is irritated to the ulnar side of the supinator longus at the external condyle of the humerus or slightly distal therefrom. It causes marked supination. This muscle being covered by others is quite difficult to irritate and in many cases it reacts only with either of the faradic poles—sometimes the anode, at other times the cathode—in which case the use of the other pole at the same point produces irritation in some other muscles, such as one of the extensors of the hand. Between the two supinator muscles, close to the most irritable point of the supinator longus will be found the point of the extensor carpi radialis longus, quite proximal to the forearm. The wrist joint is extended and turned toward the radial side. Its opponent on the ulnar side is the extensor carpi ulnaris, located closely to the ulnar border about three finger breadths distal from the olecranon process. It causes extension of the wrist but turns it to the ulnar side.

The motor point of the third extensor of the wrist which produces extension upwards,—the extensor carpi radialis brevis,—is located between the two latter extensors, nearer to the radial extensor but slightly more distal. It is difficult to irritate this muscle without also affecting the extensor communis digitorum.

The *extensor communis digitorum* will be irritated at a point about the width of a hand below the elbow joint, at the extremity of the upper third of the forearm. It extends the first phalanges of the fingers and also extends the wrist joint. Its branches supplying the separate fingers may be isolated and irritated separately. In reactions of degeneration, as in lead paralysis or radial paralysis due to pressure during sleep, the flexors of the finger are irritated at this point due to penetration of the current.

The *extensor indicis proprius*, usually covered but not connected with the former muscle, is irritable somewhat radial to the center of extensor surface of the forearm. It causes vigorous extension of the index finger.

The *extensor minimi digiti proprius* has its point external from the foregoing; it extends the small finger and slightly abducts it.

The extensors of the thumb—extensor pollicis and brevis and abductor pollicis longus—are jointly irritated near the radial border of the extensor surface, about four finger breadths above the wrist (proximal). A second point is often found to the ulnar side and somewhat proximal to the first. These muscles have the following action: The extensor pollicis longus extends the thumb and the first metacarpal bone and draws it towards the second. The extensor pollicis brevis abducts the first metacarpal bone and extends the first phalanx of the thumb. The abductor longus (with readily flexed phalanges) moves the first metacarpus forward and externally. These muscles are often isolated with difficulty.

On the flexor surface of the forearm the muscles are irritated by bending the arm at the elbow and placing the forearm in almost complete supination. The group situated nearest the ulnar side are the flexors and pronators, having origin at or about the internal condyle of the humerus.

The *flexor carpi ulnaris* point is located farthest to the ulnar side close to the border of the flexor and extensor surfaces, about the width of a hand distal from the elbow joint. It flexes the hand to the ulnar side, but does not pronate.

The *palmaris longus muscle* point is located more towards the radial side and nearer the elbow joint than the foregoing. It flexes the hand mildly, straight upwards, and its tendon is also projected in the flexed hand, to the radial side of that of the palmaris longus. A small interspace only is often found between these two tendons.

Together with these three flexors of the wrist,—which are analogous to the three extensors of the extensor surface,—at the extreme radial side may be found the motor point of the pronator radii teres, almost in the center between the radial and ulnar borders of the flexor surface, but usually a trifle nearer the ulnar border and about two or three breadths of a finger below the bend of the elbow. The location of this point in different persons shows marked variations. This muscle produces marked pronation, without moving the wrist or the fingers. This serves to differentiate it from the median

nerve which is located near it and which also causes irritation of the muscles of the ball of the thumb.

In addition to these muscles the following will be noted on flexor surface of the forearm:

The *flexor longus pollicis* is irritated at the lower third of this surface close to the radial border. Causes flexion of the last phalanx of the thumb.

The *flexores digitorum sublimis* and profundus of which the former flexes the second, and the latter the third phalanx of the fingers may be irritated at several points in the middle and lower third of the forearm. The flexors of the index finger especially, are frequently irritated by placing the electrode with some pressure between the projecting tendons of the pronator radii teres and the flexor carpi radialis, about two finger breadths above the joint.

In the arm, the *biceps* muscle is irritated with passive easy flexion of the elbow and slight pronation of the hand. Its most irritable point is located chiefly at the summit of its muscle bulk or somewhat internal and above it. It is easily irritated, producing marked flexion of the elbow and a readily perceived supination of the forearm, its action being similar and also opposed to that of the supinator longus which flexes the elbow but pronates the forearm. The third flexor of the elbow the brachialis anticus, which flexes the elbow upwards, cannot be isolated if the biceps is intact, as either the latter or the nerves in the bicipital internal sulcus respond to the irritation. Its motor point lies beneath the biceps in the lower third of the arm inwardly.

The *triceps* muscle can be irritated about the width of a hand above the olecranon, near the border of its middle and lower third. Its three heads may be irritated separately at points higher up. The action of the triceps is best noted when the elbow is placed in passive semi-flexion.

The *deltoid* muscle may be irritated in three portions of the muscle: (1) The anterior portion, slightly beneath the acromion process near the innermost border of the bulk of the muscle is readily irritated and raises the humerus forward.

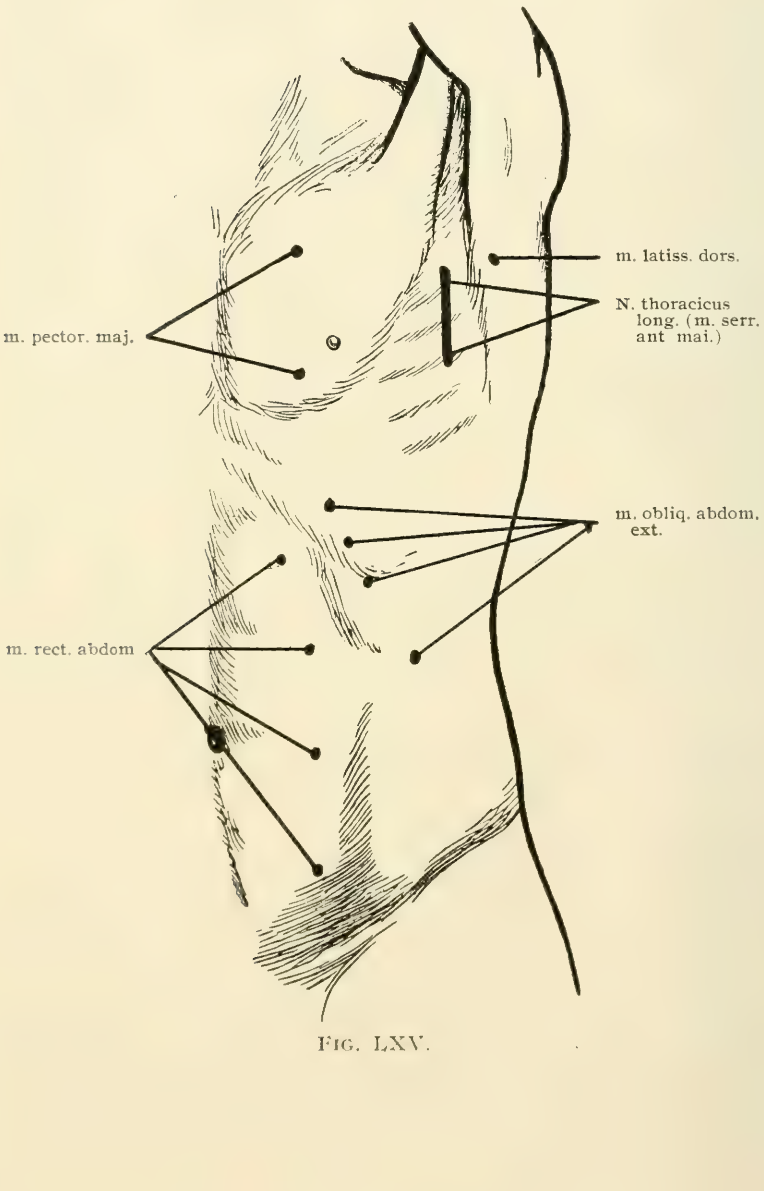

m. latiss. dors.
N. thoracicus long. (m. serr. ant mai.)
m. pector. maj.
m. obliq. abdom. ext.
m. rect. abdom

FIG. LXV.

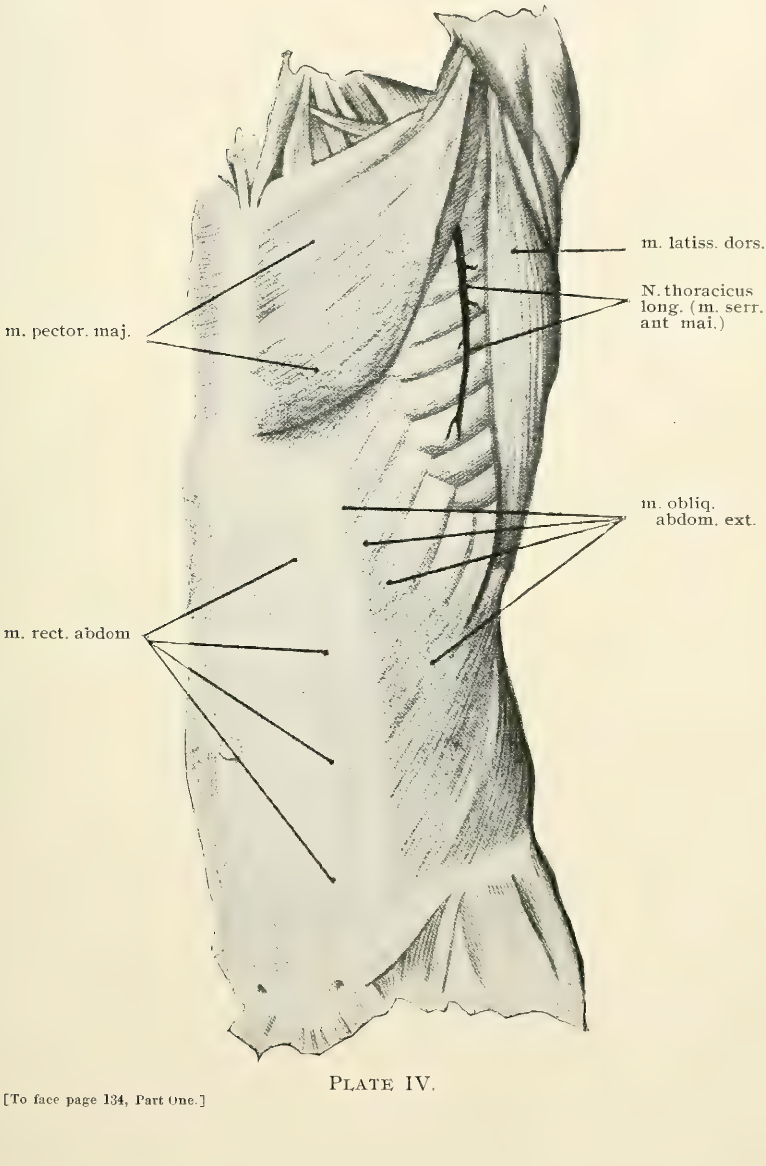


PLATE IV.

[To face page 134, Part One.]

(2) The middle portion, lateral to the former, precisely over the epiphysis, about the middle of the bulk of the muscle, raises the humerus quite vigorously to the side. (3) The posterior portion, somewhat higher and posterior to the foregoing, raises the humerus slightly to the back. The two last portions are less easily irritated than the first.

The Muscles of the Trunk: The muscles of the trunk are, with few exceptions, irritated with difficulty. As, however, several of them, especially those attached to the scapula are of great practical significance, it is essential for the practitioner to familiarize himself with the location of the motor points.

The *trapezius* may be divided into three portions:

(1) The upper portion is best irritated anteriorly at the upper border of the supra-clavicular fossa, above the point of the accessory nerve, or posteriorly at the uppermost part of the muscle. It produces chiefly inclination of the occiput to the irritated region, with lifting of the chin to the opposite side but only slight action on the shoulder. This portion of the muscle is one of the most readily irritated points of the body.

(2) The middle portion may be irritated at the level of the spine of the scapula or slightly above it, about midway between the inner border of the scapula and the vertebral column, producing vigorous elevation of the shoulder.

(3) The lower portion is irritated several finger breadths below the foregoing point, producing abduction of the scapula to the vertebral column. The second and third portions of this muscle frequently are acted upon only after the use of strong currents.

The *latissimus dorsi* muscle is best irritated with the arm by the side, inward from the lower angle of the scapula where the bulk of the muscle near the axilla reaches the lateral wall of the thorax. It adducts the dependent humerus to the thorax and draws it backwards.

The *supraspinatus* muscle can only be irritated when the trapezius is atrophied, the point being at the outer angle of the supraspinous fossa.

The *infraspinatus* muscle is irritated readily about the middle of the infraspinous fossa. It vigorously moves the humerus outward and thus aids supination of the upper extremity. With the arm hanging loosely and the forearm slightly flexed and supported its action can be well demonstrated.

The *rhomboideus major* and minor cannot be irritated directly if the trapezius is intact, but they may be acted upon indirectly through their nerve supply causing movement of the scapula obliquely from below-externally to above-internally to the vertebral column by raising the inferior angle of the scapula.

The *teres major and minor* muscles may occasionally be irritated locally, but the subscapularis muscle and the serratus posticus cannot be reached.

The *erector spinæ* muscle may be irritated at a point between the last rib and the crest of the ilium, producing inclination of the spine toward the irritated spot.

The *serratus anticus major* whose indirect irritation has already been mentioned may frequently be irritated in the axilla near its center in line with the course of the nerves. It produces projection of its serrations, pressure of the scapula to the thoracic, vigorous raising of the scapula and movement of the same anterio-externally.

The *pectoralis major* muscle (indirect irritation by means of the anterior thorax nerve) may be irritated directly at several points on the chest wall, nearer its origin than its insertion—at the clavicle, at the sternum and in the back. It produces adduction of the humerus to the thorax.

The *intercostal muscles* may be irritated by means of a very small calibered electrode at the upper borders of the intercostal spaces, causing elevation of the rib below the point of irritation.

The *rectus abdominis* may be irritated at the outer edge of its muscle bulk, about 3-4 finger breadths lateral to the median line. A point very readily irritated is located at this junction of the external border of the muscle with the ribs. It produces contraction inwardly of the abdomen at the irritated spot.

The *external oblique* muscle may be irritated at the free borders of the eleventh and twelfth rib. It produces distortion of the umbilicus to the place of irritation.

The ilio-psoas muscle cannot be irritated electrically.

The Nerves and Muscles of the Lower Extremity.—Owing to the bulk of tissue in the lower extremity, especially at the thigh, strong currents must be employed for the purpose of irritation and in obese individuals many points deeply located cannot be reached at all. The muscles must be relaxed. For examining the anterior surface the patient rests on his back in some convenient position; when examined posteriorly he rests on his abdomen. The motor points of nerves follow:

The *anterior crural* nerve will be irritated slightly below the inner third of Poupart's ligament, located quite deeply; therefore irritation is often impossible or only accomplished by means of vigorous pressure of the electrode up and backward. It produces contraction of the quadriceps extensor and of the sartorius with vigorous extension of the limb at the knee.

The *obturator* nerve is irritated above the obturator foramen internally close to the symphysis, the electrode being pressed down vigorously and strong currents employed. It produces contraction of the adductor muscles.

The *sciatic* nerve, at the posterior aspect of the thigh, can usually only be irritated in thin persons by means of strong currents and deeply placed electrodes. By drawing a line from the center of the space between the tuberosity of the ischium and the trochanter major to the center of the popliteal space, the nerve may be irritated, especially at its lower portion. It produces flexion of the leg and dorsal and plantor flexion of the foot. Flexion of the leg alone may be produced by direct irritation of the surrounding muscles.

The branches of the sciatic nerve are much more readily irritated than the trunk.

The *peroneal* nerve will be irritated at the outer angle of the popliteal space, the patient resting on his back with slightly flexed knee and the electrode being placed close to the inner border of the tendon of the biceps femoris muscle and pressure

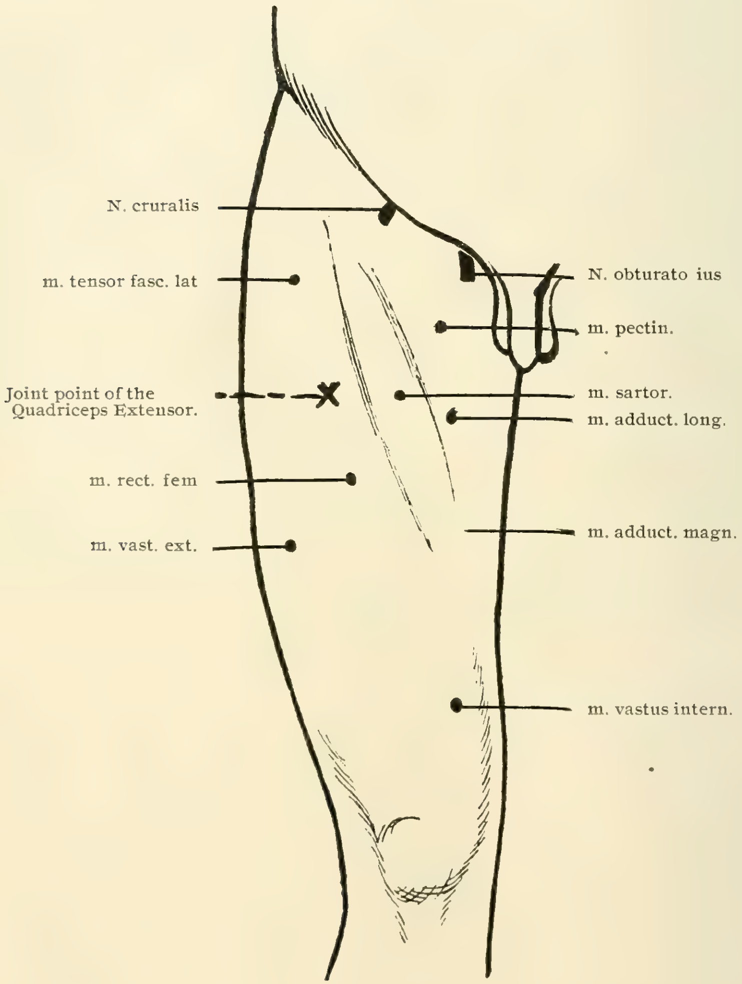
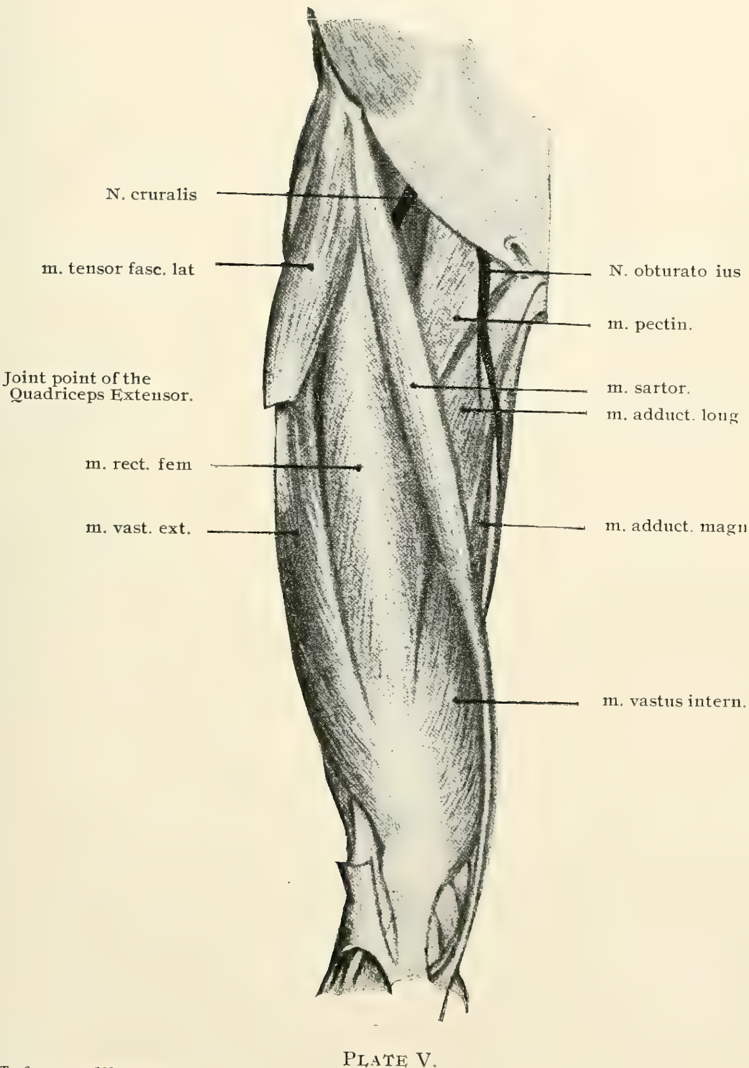

N. cruralis
m. tensor fasc. lat
Joint point of the Quadriceps Extensor.
m. rect. fem
m. vast. ext.
N. obturato ius
m. pectin.
m. sartor.
m. adduct. long.
m. adduct. magn.
m. vastus intern.

FIG. LXVI.



[To face page 138, Part One.]

Plate V.

exerted downward and inward under the tendon. From this point downwards as far as the head of the fibula and even below it this readily irritated nerve can be reached. It produces a sharp, dorsal flexion of the foot in almost linear direction with projection of the muscles and tendons on the anterio-external surface of the leg and the dorsum of the foot (peroneus longus and brevis, tibialis anticus, extensores digitorum communes longus and brevis and extensor hallucis longus).

The *tibial* nerve is readily irritated (1) in the center of the popliteal space or slightly above it. It produces contraction of the muscles of the posterior aspect of the leg and the plantar surface of the foot, vigorous plantar flexion and flexion of toes. Irritation of this nerve is usually accompanied by wrinkling of the skin covering the plantar surface; absence of the wrinkling will often be due to the fact that direct irritation of the muscles of the calf (gastrocnemius, soleus and plantaris) has taken place instead of irritation of the tibial nerve. (2) A point from which the muscles of the sole of the foot may be irritated is located close to the internal malleolus, external to the tendo Achilles.

The muscles of the lower extremity which may be noted are:

Quadriceps extensor: collective irritation of the four parts of this muscle is accomplished at the external portion of the thigh about the extremity of the upper third of the femur. It causes extension of the knee and drawing of the patella directly upwards.

The *vastus internus* may be irritated separately about a hand's breadth above the patella and the inner side of the muscle bulk. It draws the patella upward and inward.

The *vastus externus* is irritated at the outer side of the muscle but at a higher level than the former. It draws the patella upward and outward.

The *rectus femoris* may be irritated separately a short distance below the joint motor point.

The *sartorius* muscle may be irritated in the upper third or center of its length. When fairly strong currents are em-

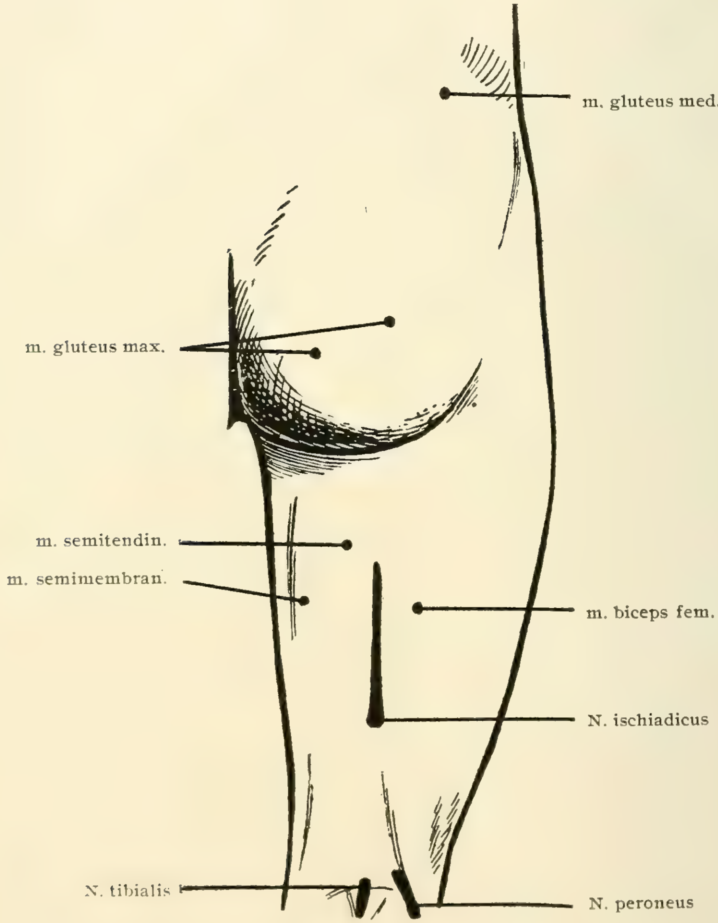

m. gluteus med.
m. gluteus max.
m. semitendin.
m. semimembran.
m. biceps fem.
N. ischiadicus
N. tibialis
N. peroneus

FIG. LXVII.

King, Electricity in Medicine and Surgery.

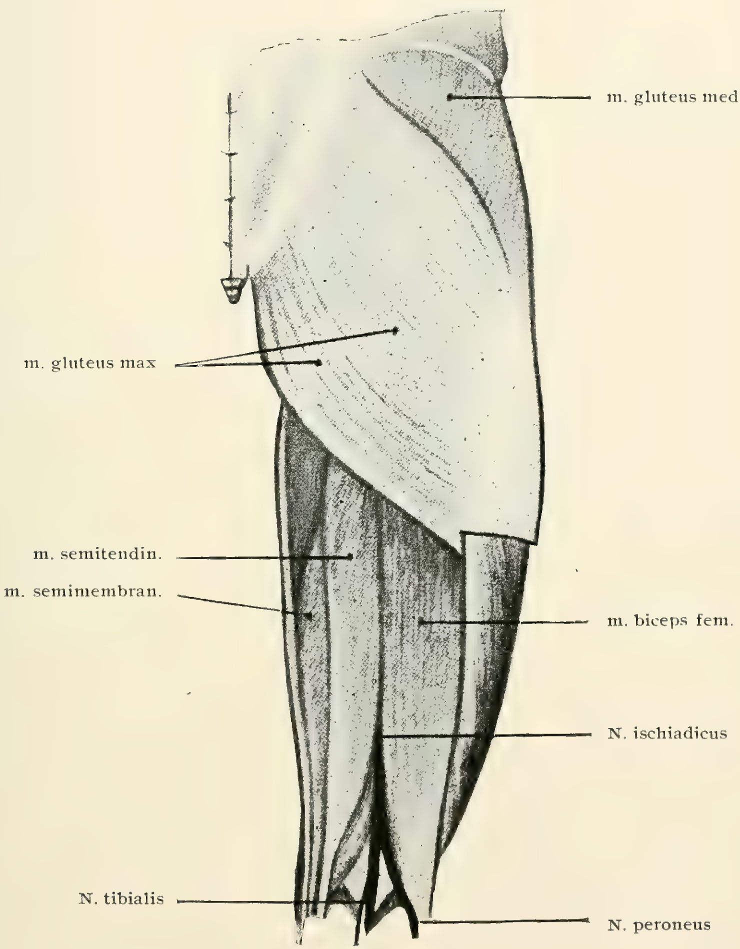


PLATE VI.

[To face page 140, Part One.]

ployed the quadriceps is irritated with it thus preventing its isolation. It produces projection of its muscle bulk; any other action is usually not obtainable.

The *adductor* muscles will be irritated at various points in the triangle bounded by the groin and the sartorius, producing vigorous adduction. They cannot be readily isolated.

The *tensor vaginæ femoris* may be irritated at the outer border of the thigh, close beneath the crest of the ilium. By employing strong currents, weak rotation inward of the limb may be noted.

The *tibialis anticus* has its point about two to three finger breadths below the patella, externally close to the crest of the tibia. It causes elevation of the inner border of the foot.

The *peroneus longus* is irritated on a level with the tibialis anticus but much more externally, beneath the head of the fibula. It produces lowering of the inner border of the foot and depression of the ball of the great toe; the latter may be readily observed by pressing the ball of the toe upward during the irritation.

The *peroneus brevis* may be irritated in line with the peroneus longus but below it at the junction of the middle and lower third of the foot. It causes weak, but well-marked, abduction of the foot.

The *extensor digitorum communis* longus is irritated about midway between the tibialis anticus and peroneus longus but more distal, about a hand's breadth below the patella. It induces abduction of the foot and causes moderate extension of the toes, the tendons of the dorsum pedis projecting.

The *extensor longus hallucis* may be irritated at a point above the ankle joint, inwardly close to the external aspect of the crest of the tibia.

The *extensor digitorum communis* brevis will be irritated on the dorsum pedis near the ankle joint quite external from the median line of the foot. It extends the toes vigorously.

The *abductor digiti minimi* is irritated external to the small toe; it abducts the small toe.

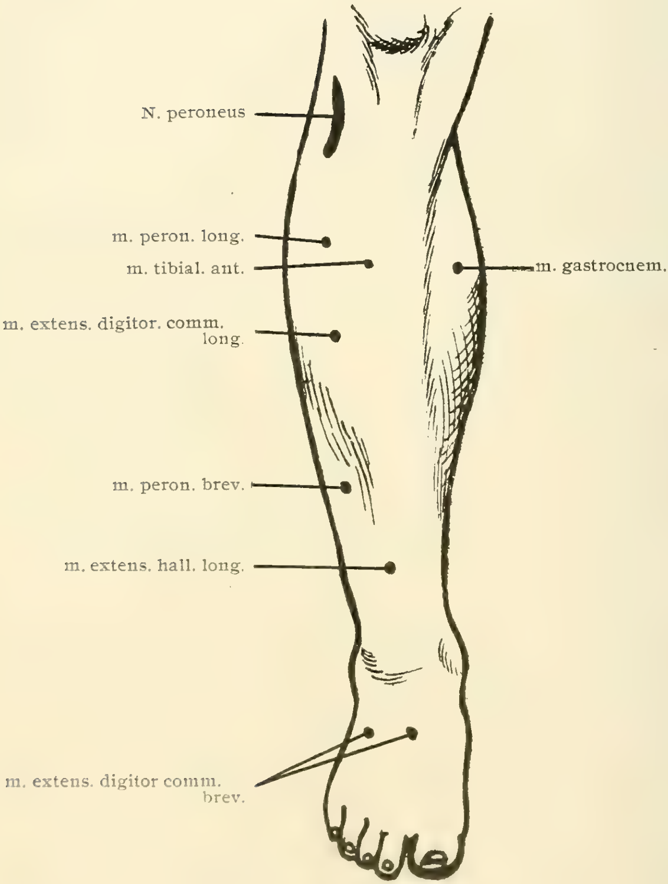

N. peroneus
m. peron. long.
m. tibial. ant.
m. gastrocnem.
m. extens. digitor. comm. long.
m. peron. brev.
m. extens. hall. long.
m. extens. digitor comm. brev.

FIG. LXVIII.

King, Electricity in Medicine and Surgery.

PLATE VII.

[To face page 142, Part One]

On the posterior aspect of the lower extremity may be noted the following:

The *gluteus maximus muscle* is readily irritated at several points on its muscle substance, most easily in its lower portion. It causes elevation and adduction of the buttocks.

The *gluteus medius may* be reached, in some cases, somewhat above the trochanter major, beneath the crest of the ilium. The patient must be examined standing, supporting himself with his hands and resting on the limb not being examined, the other limb being in a state of relaxation. When the irritation succeeds, there is extension of the hip and abduction of the limb.

The *semitendinosus and semimembranosus* muscles are irritated along the inner border of the thigh near its center, and the biceps femoris muscle slightly external to them. These three muscles usually require powerful currents and produce, as a rule, projection of their muscle bulk and tendons, the biceps being noted at the external border, the semitendinosus and semimembranosus at the external border of the popliteal space. Flexion of the leg is rarely noted.

The *gastrocnemius* muscle may be irritated at several points below the popliteal space, preferably at the lateral parts of the muscle. The foot is inflected to the plantar surface and the toes are turned inwardly.

The *soleus* muscle sometimes may be isolated by irritation of the parts not covered by the gastrocnemius at its lower portion.

The *flexor longus hallucis* is irritated external to the tendo Achilles at its inferior portion; it flexes the last phalanx of the great toe.

The *flexor digitorum* communis longus is irritated internal to the tendo Achilles, near the point for the tibialis nerve. It flexes the toes.

The muscles of the plantar region of the foot can be isolated only with difficulty by applying strong currents. As they are of but little practical value diagnostically, consideration of them is omitted.

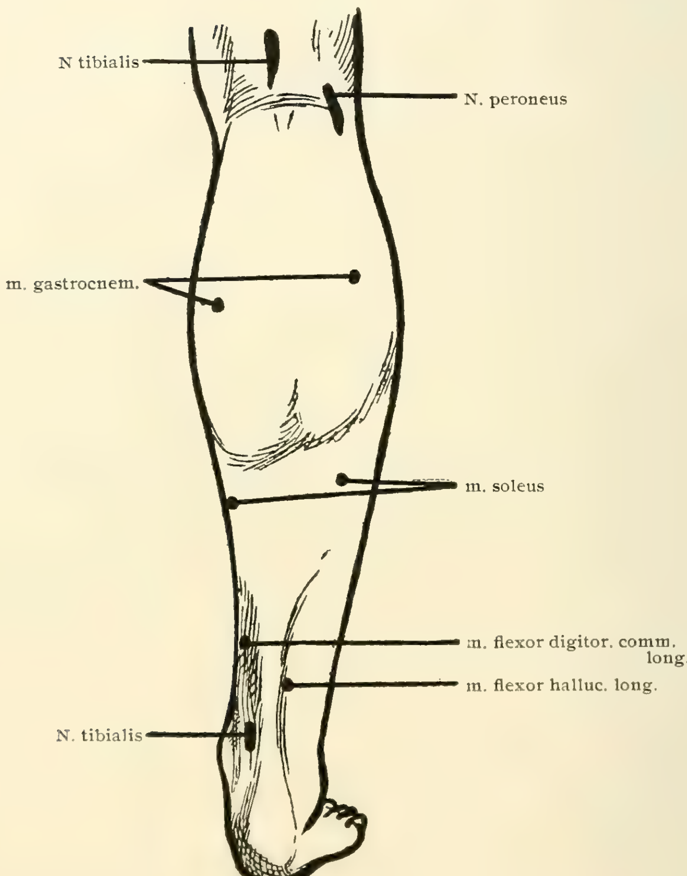

N tibialis
N. peroneus
m. gastrocnem.
m. soleus
m. flexor digitor. comm. long.
m. flexor halluc. long.
N. tibialis

FIG. LXIX.

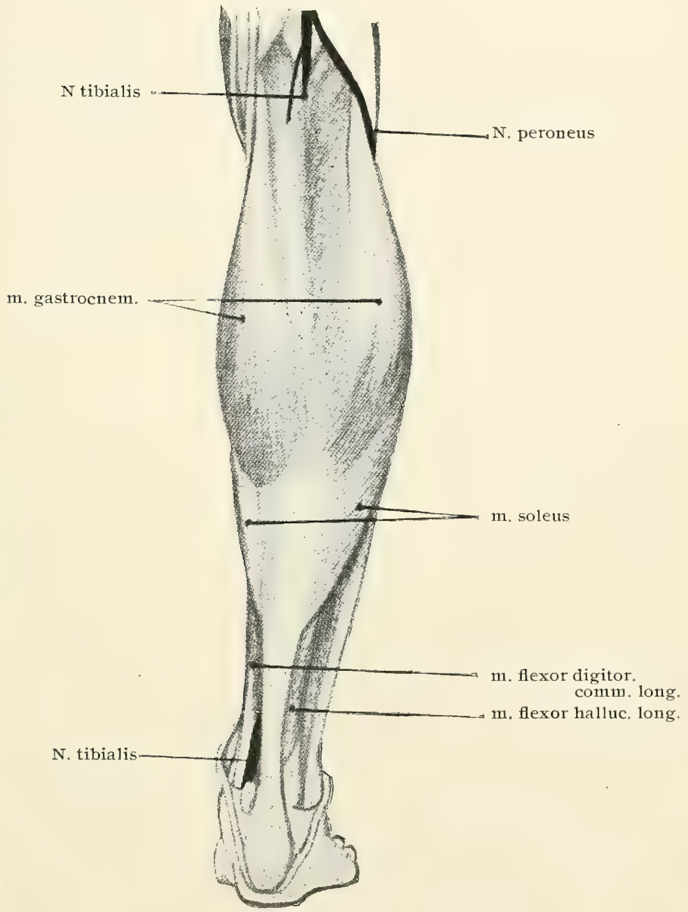


PLATE VIII.

[To face page 144, Part One.]

SECTION FOUR.

Electro-Diagnosis.

Electro-diagnosis is based upon the knowledge derived from the abnormal reaction of nerves, muscle* and the skin. The changes in the motor tract are of two kinds; first, quantitative, and second, qualitative.

Quantitative changes are simply an increase or diminution of the electrical excitability of motor nerves or muscles. An increase of excitability is made known by the nerve or muscle reacting to a current of less strength than it will in the normal state, or when with same strength of current the contractions are much stronger.

The irritability is diminished when a current of much greater strength is required to cause contraction than is required in health; or when with the same strength of current the contractions are much weaker. In quantitative increase or decrease of excitability, both nerves and muscles react in the same manner as in health; that is, the muscles contract with a quick jerk.

The same laws that govern the reaction in health apply here also, that is, ca. cl. produces contraction with the weaker current, and an. cl. and an. o. follow in the order in which they are given. There seems to be great discrepancy with different authors regarding the normal relationship of an. cl. c. and an. o. c. According to Sperling an. cl. c. produces contraction in the normal state with a less amount of current in all nerves except the radial. Here an. o. c. produces contrac-

*For the normal reaction of nerves and muscles see electro-physiology.

tion with a smaller amount of current than an. cl. c. and in this nerve only does the formula read ca. cl. c., an. o. c. and an. cl. c. This should always be borne in mind when looking for serial changes.

Qualitative changes: First, in the manner of contraction. Instead of short, jerky contraction, as in health, the contraction is long and drawn out; this is called a "modal" change. Second, the normal law of reaction to the galvanic current is changed; instead of ca. cl. producing contraction with the weakest current, an. cl. may do so; or the two may produce equal contraction with the same strength of current; or it may be that ca. cl. still leads, though the difference between them is less; instead of two or three milliamperes more being required with an. cl. only a half of a milliampere may be required, while in very severe cases an. o. may produce contraction before ca. cl. This is known as a "serial" change.

Reaction of Degeneration (designated R. D.).—Reaction of degeneration is a term given to a cycle of changes in the reaction of nerves and muscles, which when taken in their entirety, and in some cases when taken only partially, indicates certain lesions within the motor tract. As the reaction of the nerves and muscles in R. D. differ, it is necessary to consider them separately.

Changes in the Reaction of the Nerves.—The change in the reaction of nerves is a quantitative diminution to both galvanic and faradic currents alike. This decrease is either rapid or slow, according to the acute or chronic character of the disease. In an acute disease, such as a recent attack of infantile paralysis, or in a severe traumatic lesion of a nerve trunk, there is a rapid decrease in the electrical excitability from the first, which may become completely lost in one or two weeks; while with a chronic or sub-acute affection, it may be months or years before it is lost.

The period during which a nerve remains unexcitable varies with the nature and extent of the lesion which causes it. There are rarely any qualitative changes in the reaction of the nerves, but a modal change may be observed—that is, the

contraction, instead of being quick and jerky, may be long and drawn-out or feeble.

Changes in the Reaction of Muscles.—With the muscles we have a more characteristic phenomenon. When a faradic current is applied direct to a healthy muscle, that muscle is made to contract by the stimulation of the intra-muscular nerve fibers —the muscular fibers not being stimulated by currents of such short duration as those of which the faradic current is composed. It is, therefore, evident that the faradic current follows exactly the same course when applied to a muscle as it does when applied to a nerve. It has been shown that as the nerve degenerates it gradually loses its excitability to both galvanic and faradic currents, and, as the intra-muscular nerve fibers degenerate along with the trunk of the nerve, the faradic current will lose its exciting power when applied to one the same as when applied to the other. But, as the degeneration of a nerve begins at the point of injury and moves toward the periphery, it follows that the intra-muscular nerve fibres will be the last to degenerate, and, consequently, it loses faradic irritability somewhat later than does the nerve, the difference varying with the character of the disease—being slight in acute, but longer in chronic diseases.

Muscular fiber is capable of being stimulated by the galvanic current, irrespective of the nerve which supplies it, and the changes in reaction which take place in it in R. D. are highly characteristic. The changes are both quantitative and qualitative. The quantitative change differs in acute and chronic affections; with the former there is at first a slight diminution in the excitability, but this is soon changed to an increase of excitability, and may even become so marked that only two or three ma. will be required to cause contractions that require ten or twelve in health or if the disease is unilateral on the healthy side. This over-excitability may persist for several weeks, when it gradually returns to normal or below normal, and in incurable cases the excitability may be lost. With chronic affections there is a gradual diminution of excitability from the first.

Qualitative changes consist, first, of a modal change, that should be carefully looked for, as it is often the only indication in slight affections that R. D. is present. The serial changes in R. D. are the most characteristic.

There is a form of partial R. D. which is only manifested by the qualitative changes in the muscles, the nerves reacting normally to the galvanic and faradic currents, and the muscles also retaining their faradic excitability. This occurs when the injury or disease is very slight. The accompanying cut, Fig. LXX, taken from Erb, illustrates the R. D. The ordinate, *O*, indicates the starting point or commencement of the disease; the galvanic and faradic excitability of the nerve is indicated

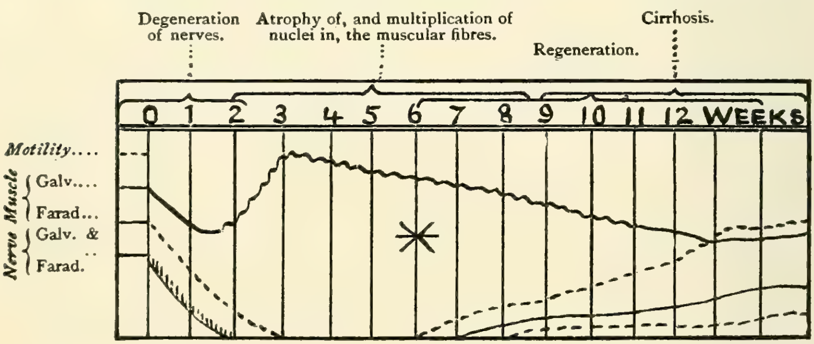


FIG. LXX.

by the lower line. The galvanic and faradic muscular excitability are indicated by separate lines. The wave of the galvano-muscular line shows the periods of qualitative changes. At the top are given the various histological changes that the nerve undergoes during the stages of degeneration and regeneration.

Methods of Determining Qualitative and Quantitative Changes.—As the usefulness of electro-diagnosis depends entirely upon the care and accuracy with which it is carried out and the avoidance of all sources of error, we have thought it advisable to give certain rules which, if carefully followed, will greatly assist the operator:

I. Good light is essential; the milliampere meter especially, must have a bright light. The operator should stand or sit so as not to interfere with the proper exposure of the parts to be examined.

II. The muscles to be examined must be relaxed; the injunction to relax must be constantly repeated. Relaxation is rendered more easy by a comfortable recumbent or semi-recumbent position.

III. The electrodes must be of suitable size, well moistened and placed evenly on the tissues. They should be relatively increased in size as the distance of the nerve from the epidermis increases. Parts located deeply, therefore, require large electrodes. (See electrodes in preceding section.)

IV. The inactive electrode is placed preferably over the lower sternum, owing to the scarcity of nerves and muscles in that location.

V. The irritant electrode must be small, to obtain increased intensity, but the inactive electrode quite large.

VI. The faradic current is applied first, for, unlike the galvanic, it does not alter the resistance of the skin; then follow with the galvanic current.

VII. When applying the electrode the spring of the interrupting handle must be so constructed as to have an open circuit when not in use. The electric force is turned on, first of moderate strength and gradually increased, or the secondary coil is shoved over the primary. The interrupter is then used to close and open the circuit, when, if there be sufficient current strength, contraction is obtained. The circuit is closed only sufficiently to note the contraction of the muscle, when it should be immediately opened.

VIII. The skin directly over bone, as in the forehead or at ulnar and peroneal nerves, is particularly sensitive; hence closure on these parts must be very short.

IX. Severe pressure is rarely required, excepting where nerves are deeply located, as the radial and facial nerves.

X. In examining about the face, it is advisable to hold one hand against the side of the face not involved in the examina-

tion so as to prevent movement. In examining the muscles around the mouth, the latter should be slightly opened.

XI. Diminished irritability should only be diagnosed when it is noted after repeated examination. Special care is necessary in lesions where both sides are affected. In these cases Stintzing's tables must be consulted. Marked deviation from the average irritability as given in these tables will point to pathological changes in the parts involved. When the examition shows variations the fault is with the operator in not getting uniform pressure and accuracy over the motor points.

XII. The most reliable and chief symptom of R. D. is the modal change in contraction, evidenced by sluggish and weak contractions of the muscles.

XIII. It must not be forgotten that the motor points of muscles sometimes change in position; in such cases the muscle must not be irritated at the entrance of the nerve into the muscle, but nearer to the periphery at the tendinous insertion of the muscle.

XIV. Stintzing's tables of faradic and galvanic irritability and Erb's table of cutaneous sensibility do not apply to the newly born.

Qualitative Changes.—Modal changes will perhaps better be understood if we take a nerve—as the facial for example—and examine it in detail. The inactive electrode, generally the positive, is thoroughly moistened and placed over the sternum where it is firmly held in position by the patient. To a small electrode—one of Erb's given in the section on Motor Points is best—is fastened a handle that has a key attached by means of which the circuit may be interrupted at will. This is attached to the negative pole. The muscles on the healthy side are first examined. Here we find that on closure of the circuit the muscles contract energetically and in bulk; that the contraction reaches its height immediately—that is so far as the eye can distinguish—and that the relaxing is of the same uniformity and rapidity. In this case the muscular fibers have been made to contract through the stimulus of the intra-muscular nerve fibers, which in turn have received their stimula-

tion through the electrical impulse on the closing of the circuit, with the result that each fiber and bundle of fibers have worked simultaneously and harmoniously, producing a uniform contraction in a mass. We now remove our electrode to the diseased side which exhibits modal changes. After the electrode has again been moistened, we place it on the diseased muscle and again close the circuit. We now find that instead of the quick contraction in mass we have a feeble, long-drawn-out contraction, in fact a slow wavering contraction which reaches its summit almost by stages and remains at its summit for a perceptible period, when it relaxes in the same slow wavering manner in which it arose. Now in this case the nerve is gone. The muscle fibers are made to contract by the direct stimulus of the current upon them and since they lie at different depths the resistance to them differs; as a result the stimulus is not simultaneous and uniform in degree. Consequently each bundle of fibers is contracting independently of all the others, and this gives the slow wavering appearance to the contraction. The phenomenon of the muscle remaining at the summit of contraction for a perceptible period is probbly explained, upon the theory that inasmuch as all muscle fibers do not contract simultaneously they reach their zenith of contraction at different periods, and while the fibers which first contracted may immediately relax, others are coming up to their zenith just at that time, so that the bulk of contraction is maintained until all have reached their zenith, when we get the same wavering relaxation.

Serial changes may also be easily determined by comparison. We leave the inactive electrode—which is again positive—over the sternum. After again dipping the negative electrode into water, we place it over a muscle on the healthy side of the face, say the buccinator. We turn on sufficient electric force so that when the circuit is closed by the key in the handle, a good contraction is produced and the number of milliamperes passes is noted. Without removing the electrode, we reverse, by means of a pole changer, the direction of the current, which now makes the nerve electrode positive.

Again the circuit is closed and the contraction is again noted with the number of milliamperes required and this is repeated on the opening of the circuit. It may be well for one who has had but little practice to repeat these experiments several times until the degrees of contraction produced at ca. cl., an. cl. and an. o. are familiar to the observer's eye. Now the nerve electrode is once more carried to the diseased side and the same observation again carefully noted under the same closures and openings. It may be necessary to go back to the healthy side one or more times. By this means very slight serial changes may be noted.

Quantitative Changes.—With the quantitative changes one can never become so well practiced as to be able to determine them unless they are well marked, and it will not do to compare any two persons; therefore, we must take some more accurate method of comparison. We may here repeat some of the more important points to be guarded against to avoid error. The inactive electrode should be placed in the median line, so that the resistance will be the same on both sides of the body; the active electrode should be placed directly over the motor point, and all other things which tend to make a difference in the resistance to the current should be carefully avoided. The circuit should be made and broken with the same suddenness in each case; the parts examined should be in an equal state of relaxation, and the patient's will power should not in any way assist or retard the contraction. Over the sternum is the best place to put the inactive electrode, as there it does not produce discomfort, is in the centre of the body, and can be held by the person examined. The active electrode should be equally well moistened every time it is changed, care being taken that the skin is as well moistened in one place as in another, thus removing all source of error. When the disease is unilateral, comparison with the healthy side is easy, and very slight quantitative changes can be ascertained; but when the disease is bilateral, we are compelled to seek some other means of comparison. Erb first instituted comparison of different parts of the body. He found that there was con-

siderable uniformity between the reaction of the facial, spinal accessory, ulnar and peroneal nerves in a healthy individual, and that any great departure from this normal relationship was the result of some pathological condition. Erb's method was to place a galvanometer in the circuit, and, with a certain number of cells, note the deflection of the needle.

Since Erb's experiments, the milliampere-meter, which accurately measures the current has been introduced. Some years ago we instituted another method of making a comparison of these different nerves. Our method is, first to observe all the details just given, in order to avoid any source of error, although this is not so essential as it is in Erb's method. A larger electro-motive force is turned on than is needed to produce the required contraction. A rheostat, capable of very fine adjustment, and a dead-beat milliampere-meter, with a registering scale graded to one-fifth of a milliampere, is placed in the circuit. The current is then graduated by means of the rheostat until it is sufficient to produce slight contractions. The circuit is then closed for ten seconds, when the needle will have become quiet; the register is then taken. No matter if the needle should become quiet before the ten seconds expire, do not read the register before, as the longer the circuit is closed, owing to the decrease of resistance, the more the current will measure. It is, therefore, necessary to have some stated time for the current to pass before it is closed and the register taken. With the instrument we use the needle becomes quiet in ten seconds under all circumstances; therefore, we have chosen that period of time. A large, flat electrode, well moistened, is placed on the sternum; then the active electrode is successively applied to the motor points of the following nerves, and each is in turn stimulated.

Following are Stintzing's tables, showing the scale of irritability of the principal nerves. The tables show the ratio of irritability as maintained throughout the list, the accessory and musculo-cutaneous nerves being very readily irritated while the facial and radial require a relatively marked increase of current:

GALVANIC IRRITABILITY OF NERVES.

		Minimum.	Maximum.		Average.	
1. Musculo-cutaneous nerve		0.05 ma.	1. do.	0.28	1. do.	0.17
2. Accessory		0.10 ma.	2. do.	0.44	2. do.	0.27
5. Ulnar	I	0.20	3. do.	0.90	3. do.	0.55
4. Peroneal		0.20	4. do.	2.00	4. do.	1.10
5. Median		0.30	5. do.	1.50	5. do.	.90
6. Crural		0.40	6. do.	1.70	6. do.	1.05
7. Tibial		0.40	7. do.	2.50	7. do.	1.45
8. R. Mental		0.50	8. do.	1.40	8. do.	.95
9. Ulnar	II	0.60	9. do.	2.60	9. do.	1.60
10. R. Zygomatic		0.80	10. do.	2.00	10. do.	1.40
11. R. Frontal		0.80	11. do.	2.00	11. do.	1.45
12. Radial		0.90	12. do.	2.70	12. do.	1.80
13. Facial		1.00	13. do.	2.50	13. do.	1.75

In making an electro-diagnostic test with the faradic current, we use the Du Bois-Raymond coil, with the scale that marks the distance, the secondary coil is placed over the primary, graduated in millimeters.

This table is, of course, only pertinent to Stintzing's instrument, but it nevertheless shows the relative irritability of the various nerves and can thus be used in connection with any instrument.

FARADIC IRRITABILITY OF NERVES.

			Maximum.		Minimum.	Average.	
1. Accessory Nerve			145.	1. do.	130.	1.	137.5
2. Musc. Cut.	"		145.	2. do.	125	2.	135.
3. R. Mental	"		140.	3. do.	125.	3.	132.5
4. Ulnar	"	I	140	4. do.	120	4.	130.
5. R. Frontal	"		137	5. do.	120.	5.	128.5
6. R. Zygomatic	"		135	6. do.	115	6.	125
7. Median	"		135	7. do.	110	7.	122.5
8. Facial	"		132	8. do.	110	8.	121.
9. Ulnar	"	II	130	9. do.	107	9.	118.5
10. Peroneal	"		127	10. do.	103	10.	115
11. Crural	"		120	11. do.	103	11.	111.5
12. Tibial	"		120	12. do.	95	12.	107.5
13. Radial	"		120	13. do.	90	13.	105.

The Occurrence of Changes in Reaction and Their Practical Application: First Simple Increase and Diminution of Electro-Excitability Without the Peculiar Phenomena which Indicate R. D.—A simple increase of irritability is found in cerebral paralysis of recent origin. It is also occasionally found in the last stage of locomotor ataxia some months before any other symptom appears to corrobrate the diagnosis; but it is not of constant occurrence. The most striking example of increased irritability is found in certain forms of spasms, such as tetany. Cohn also states that increased irritability has been found in several peripheral nerve paralyses, especially those deeply located—as the facial and radial—; in the latter case the increased irritability lasted for several days. He does not state the exact nature of the paralysis pathologically, though that would be very interesting.

Simple diminution of electrical excitability, quantitative decrease, does not occur in cerebral paralysis except in those cases where the disease is of long standing and is associated with descending changes. If it exists to any degree, the disease is not purely cerebral. It also occurs in certain spinal affections, such as locomotor ataxia of long standing and diseases affecting the white matter of the cord, such as spastic paralysis, myelitis, multiple sclerosis or any other disease not affecting the gray neuclei of the anterior horns; but in all these diseases reaction may be normal, so there is nothing of a specific diagnostic character in the diminution of excitability. It is of very frequent occurrence in that class of diseases which come under the orthopædic surgeon's hands as the result of spinal affection; also, below the point of the lesion in transverse myelitis affecting the whole thickness of the cord, when due either to disease or traumatism, in this case the nerves and muscles under the direct influence of the diseased portion of the cord will show signs of R. D.

Muscles exhibit diminution of electro-excitability from disuse, in chronic joint affection, also after a fracture or surgical operation which requires the limb to be kept in position for a time. The practical importance of the occurrence of diminu-

tion, besides its contra-indicating purely cerebral disease, proves that it is positively not hysterical, and also that the patient is not shamming. At the same time the absence of any change in reaction, it should be remembered, does not prove that the patient is shamming. The same is true in increased irritability. At times, however, the disease feigned is one that has distinct changes in reaction. This is easy of detection. For instance, if a paralysis be feigned that would naturally involve the grey nuclei of the horns and the reactions were found to be normal, the patient would certainly be shamming. Simple diminution is also found where the disease is referred to the muscle substance itself, as in progressive muscular dystrophy or myopathic progressive atrophy,—in contra-distinction to spinal progressive muscular atrophy. In the latter R. D. may be present, excepting where the atrophy is of very slow progress and the degeneration of the muscle fibers affects but a small part of the whole bulk of the muscle, as when the normal contractions of the healthy fibers mask the abnormal contraction of the fewer diseased fibers. This fact also holds good in other affections, as in poliomyelitis chronica, amyotrophic lateral sclerosis, progressive bulbar paralysis, etc. If R. D. is found, the diagnosis is conclusive; if in doubful cases it is not found, these diseases cannot be excluded; if simple diminution of irritability without qualitative change is noted, a muscular process may be suspected but not determined; if R. D. is noted, spinal involvement can safely be diagnosed.

Absolute absence of irritability of a muscle shows that its contractile area has been destroyed. This may follow R. D. or progressive diminution of irritability. Absence of irritability of a nerve does not indicate anything referring to its muscle; the latter requires a separate examination to determine its condition.

The following table which we have compiled will serve to illustrate the diseases which may be present when simple quantitative changes are present:

	Diseases of Cerebral Origin.	*Diseases of Spinal Origin or of the Peripheral Nerves.*
Increase of faradic contractility.	Cerebral paralysis (recent hemiplegia.) Athetosis. Little's disease. Commencing hysterical paralysis.	First stage of locomotor ataxia; commencing myelitis. Neurasthenia of spinal origin. Tetanus. Chorea. Certain peripheral nerve paralyses (facial and radial).
Increase of galvanic contractility without R. D.	Cerebral paralysis (recent hemiplegia).	First stages of locomotor ataxia. Commencing myelitis. Neurasthenia of spinal origin. Tetanus. Chorea. Certain peripheral nerve paralyses (facial and radial).
Diminution of faradic contractility.	Chronic hemiplegia (following apoplexy, degenerations, etc. Chronic hysterical paralysis.	Chronic locomotor ataxia. Myelitis. Spinal sclerosis. Paralysis agitans. Peripheral neuritis. Atrophy following pressure on a nerve trunk or due to neuralgia. Obstetrical and rheumatic paralysis. Mild facial paralysis.
Diminution of galvanic contractility without R. D.	Chronic hemiplegia. Chronic hysterical paralysis.	Chronic locomotor ataxia. Paralysis agitans. Mild diphtheritic paralysis. Progressive muscular atrophy. Atrophy following compression of muscles (fractures) or of a nerve trunk or due to neuralgia. Mild obstetrical paralysis. Rheumatic paralysis.

Reaction of Degeneration.—When R. D. is present, it indicates one of two things—that the motor nerve or the grey matter of the anterior columns of the spine is the seat of disease. It further shows that there is more or less degenerative atrophy of one or both of them. The most typical cases of R. D., when the motor nerve is the seat of the disease, are found in severe traumatic lesions causing section or rupture of it.

The following tables compiled from Erb, show the relative pathological changes in the muscles and nerves and their respective electrical reaction in nerve lesions:

Pathological Changes in the Paralyzed Nerve.	*Electrical Reaction in the Paralyzed Nerve.*
(1) The degeneration at the seat of the lesion is at once followed by degeneration of the severed peripheral nerve; (2–4 days after the traumatism) with breaking down of the medullary sheath and disintegration and dissolution of the axis-cylinder.	(1) Equal and progressive diminution of the faradic and galvanic irritability (from 2–3 days after the traumatism).
(2) Complete degeneration of the nerve: complete breaking down of the medullary sheath as well as the axis-cylinder; degeneration of the motor end-bulbs; inflammatory proliferation in the sheath of Schwann.	(2) R. D. Complete loss of irritability of the nerve (in the course of the second week of the disease).

These Conditions are Followed by,

Either:

(*a*) Beginning regeneration at the the same time at the seat of the lesion and in the peripheral nerves, possibly primarily in the motor end plates. This is followed by complete regeneration; restitutio ad integrum.	(*a*) Gradual return, progressively, of evidences of irritability. With diminished electrical reaction for a long time.

Or:

(*b*) Changes in the intense inflammatory proliferation in the sheath of Schwann in the connective tissue of the perineurium which destroys the whole nerve structure ending in connective tissue degeneration, cirrhosis of the nerves (incurable case).	(*b*) Permanent complete loss of irritability of the nerves.

Pathological Changes in the Paralyzed Muscles.	*Electrical Reaction of the Paralyzed Muscle.* *Faradic.*	*Galvanic.*
	Uniform, progressive diminution of irritability,	
(1) Commencing atrophy of the muscle: diminution of the muscle fibers, loss of the striations and increase of the nuclei.	(from 2–3 days after the traumatism). *R. D.*	(*only* in the course of the first week).
(2) Increasing atrophy; histological and chemical changes in the muscle substance (waxy degeneration): increase of the nuclei and connective tissue proliferation about and in the muscle resulting in *either:*	(2) Discontinuance of faradic irritability (in course of the second week). Followed by *either:*	*Increase* in galvanic irritability, sluggish contractions, an. cl. c. replaces ca. cl. c. (commences during the second week and has its maximum increase in the fourth to fifth week).
(*a*) Regeneration, restitutio ad integrum,	(*a*) gradual traces of returning irritability;	(*a*) gradual diminution of galvanic irritability until below normal.
	diminished irritability with both currents for a long period;	
or: (*b*) In connective tissue degeneration (incurable case).	(*b*) continued disappearance of faradic irritability.	(*b*) Constantly diminishing galvanic irritability until complete discontinuance of same.

Severe pressure, which causes a change in the nutrition of the nerve, produces R. D.; mild pressure, not sufficient to cause any change in the nutrition, may cause paralysis, but no R. D. Certain interstitial changes in the nerve will cause R. D. An example of the latter is facial paralysis when that is of a rheumatic origin, which causes some parenchymatous changes in the nerve, or when it is due to a blast of cold air on the face, causing an effusion into the nerve sheath.

R. D. occurs in all spinal diseases which affect the gray anterior column of the spine, whether acute, subacute, or chronic, such as anterior poliomyelitis, chronic progressive bulbar

paralysis and amyotrophic lateral sclerosis. It is present in spinal hemorrhage and in some forms of chronic myelitis, but only when they affect the gray anterior columns. It should be remembered that R. D. is sometimes present when no paralysis exists, and that great atrophy of muscles may exist without exhibition of R. D., and, also, that motion is sometimes restored before electrical reactions return.

We have seen that the presence of R. D. does not tell the particular disease from which the patient is suffering, but locates its cause in the motor nerve, or in the gray anterior column. If the disease is due to the former, only those muscles supplied by it exhibit R. D.; but, if the latter is the seat of disease, we are very apt to have R. D. in muscles supplied by more than one nerve. This brings it down to a very few diseases, and these can be easily distinguished by other diagnostic points. After carefully studying the preceding pages, one can plainly see that valuable deductions can be drawn from abnormal reactions in regard to prognosis. It should be understood that in all grades of R. D. from a slight modal change to a complete loss of reaction, in the same disease and due to the same causes, the disease will be found to be of longer duration and in every respect more severe the later the stage of the disease in which it is found and the more complete the R. D.

According to Sperling the importance in diagnosis of R. D. has been shaken by the discovery that it is found in trichinosis and in hysterical paralysis; this, however, needs more confirmation.

In Thomson's disease (Myotonia congenita) according to Cohn myotonic reaction is noted. The nerves react normally both qualitatively and quantitatively, the changes in the muscles being a peculiar continuation of contraction after the use of a moderate faradic current. The galvanic current produces ready irritability, but contraction is obtained only on closure; the anode and cathode both cause slow contractions which persist after the application of the current.

Diseases of central origin in which R. D. is noted may be classified as follows:

(1) Diseases of the medulla oblongata, such as the various bulbar-paralyses—acute, chronic, progressive—hemorrhages and degenerations at the base of the brain; also in inherited or early acquired cases of facial paralysis.

In these cases R. D. is, of course, only found in the region of the affected cranial nerves.

(2) Diseases in which the cells of the anterior horn of the cord are attacked.

(*a*) Acute anterior poliomyelitis—Infantile spinal paralysis. This is differentiated from infantile cerebral paralysis as the latter does not present R. D. and may merely have diminished irritability or no anomalous electrical reaction at all.

(*b*) Poliomyelitis anterior, subacute and chronic.

(*c*) Progressive spinal muscular atrophy sometimes; in myopathic muscular atrophy R. D. is usually absent. The test is not decisive in these diseases.

(*d*) Hemorrhages and softenings in anterior horn.

(*e*) Gliomata—syringomyelia, Morvan's disease.

(*f*) Inflammation of the whole cord transversely (myelitis transversa).

(*g*) Amyotrophic lateral sclerosis. Spastic spinal paralysis does not produce R. D.

(*h*) Diffuse areas, if of an inflammatory or sclerotic character, will, when located in the anterior horn, produce R. D. in the muscle supplied by the region affected.

(3) Diseases affecting the roots of the cranial or spinal nerves; meningeal lesions of various kinds when accompanied by marked involvement of the nerve trunks; diseases affecting the vertebræ, as tuberculosis or tumors arising from the vertebræ or meninges and involving the nerves. Such cases are quite rare.

(4) Diseases of the peripheral nerves:

(*a*) Injuries, especially if due to a bruise or pressure; such as paralysis of the nerves of the arm following pressure during sleep, peroneal paralvsis due to parturition and paralysis of the ulnar and median nerves due to shackels or chaining;

paralysis induced through carrying of loads on shoulders or back; paralysis due to pressure of callus or tumors.

(*b*) Severing of the nerves; especially those of the upper extremity due to sword cuts; also operative injuries as section of the facial nerve during operations on the glands.

(*c*) Injuries due to chemical agents, such as incurred during injection of morphine or cocaine.

(*d*) Inflammation of the peripheral nerves, such as those following middle ear diseases in which there is paralysis of the facial nerve; inflammation of toxic character as found in lead poisoning, arsenical poisoning or alcoholic neuritis; inflammation following specific infection as diphtheritic neuritis, and neuritis following la grippe and beri beri; atrophies following certain occupations must also be mentioned.

(*e*) Tumors of the peripheral nerves (quite rare).

According to the severity of the lesion, which is dependent on the greater or lesser rapidity of development, several varieties of R. D. may be differentiated.

(1) The complete form in which all the phenomena are clearly noted.

(2) The partial form in which the symptoms are merely outlined.

Complete R. D. may again, in a general way, be subdivided into mild, moderately severe, and severe forms. The two former are curable, the latter incurable.

The course of these forms of R. D. may best be illustrated by the following table as arranged by Cohn:

I. Complete R. D. Mild and moderately severe (curable) forms:

	Irritability of Nerves.		*Irritability of Muscles.*	
	Faradic.	*Galvanic.*	*Faradic.*	*Galvanic.*
(1) First Stage.	Towards end of the week diminution of irritability moderate.		Diminution of irritability, somewhat later.	
(2) Second Stage: 2-5-15 week.	Absent.	Absent.	Absent.	*Increased sluggish;* an. cl. c. replaces ca. cl. c.

	Irritability of Nerves.		*Irritability of Muscles.*	
	Faradic.	*Galvanic.*	*Faradic.*	*Galvanic.*
(3) Third Stage: 6–12–16–30 week.	Towards the end of period. Return.	Return.	Towards end of period, return.	Diminution until normal; quicker contractions, an. cl. c., ca. cl. c., then normal series is restored, ca. cl. c., then an. cl. c., etc.
(4) Fourth Stage: later.	Subnormal.	Subnormal.	Subnormal.	Subnormal (no subsequent qualitative changes).

II. Complete R. D. Severe—(incurable) variety.

1st and 2d stage like above table; this is followed by

	Irritability of Nerves.		*Irritability of Muscles.*	
	faradic	*galvanic.*	*faradic.*	Galvanic
3d Stage: 6th week and later.	Remains absent.	do.	do.	diminution to entire cessation; contractions remain sluggish. An. cl. c. replaces ca. cl. c.

III. Partial R. D. (curable).

	Irritability of Nerves.		*Irritability of Muscles.*	
	Faradic.	*Galvanic.*	*Faradic.*	*Galvanic.*
1st Stage: 1st week,	Normal or diminished.	Normal or diminished.	Normal or somewhat later diminished.	Normal ro somewhat later diminished.
2d Stage: 2d–5th week,	Normal or diminished.	Normal or diminished.	Normal or diminished.	Increased sluggish contration. An. cl. c. replaces ca. cl. c.
3d Stage: 6th–12th week,	Becomes normal.	Becomes normal.	Becomes normal.	Becomes normal.
Or in progressive lessions (incurable):				
3d Stage: 6th week and later,	Diminished until cessation.	Diminished until cessation.	Diminished until cessation.	Diminished until cessation; contraction remains sluggish. An. cl. c. replaces ca. cl. c.

Differential diagnosis and prognosis: (1) The differential diagnosis between the incurable and the moderately severe curable variety of R. D., can only be made after the 8th-10th week, frequently only after the 15th-20th week. If at these periods, irritability returns in places where it had ceased, or contraction is noted in any of the affected muscles—even if it required a strong faradic current to bring this about—a favorable prognosis—indicative of the curable form of R. D.—can be hazarded. If, however, these features are absent, it is essential to watch the modality of the galvanic contraction. If the galvano-muscular irritability diminishes and the contractions become more normal, the prognosis as a whole is favorable.

If, on the other hand, the galvano-muscular irritability diminishes and the contractions remain sluggish or become more so, the prognosis is unfavorable, and the incurable variety of R. D. can be diagnosed. It is best to delay making an unfavorable prognosis as long as possible for return of irritability and normal contractions have been known to occur after the lapse of a year or even later.

(2) R. D. is of special prognostic importance in certain varieties of peripheral paralysis, such as the so-called rheumatic facial paralysis and certain pressure paralyses, as the radial paralysis due to pressure while sleeping on the arm. These forms of paralysis are nearly all curable and may be divided into three groups:

(*a*) Paralysis without R. D.; curable in 2-3 weeks.

(*b*) Paralysis with partial R. D.; curable in 6-12 weeks.

(*c*) Paralysis with complete R. D. (usually of the moderately severe variety); requires about 6-9-12 months for a cure.

In every such case a prognosis can be given to the patient during the second week. If at this period normal electrical reactions are noted the case belongs to group a. If partial R. D. is noted, the lesion will be ameliorated by the eighth week. If, on the contrary, faradic irritability is absent and galvano-muscular R. D. is noted, from six to nine months at least, are required for a cure.

(3) In most cases of spinal and bulbar (especially progressive) diseases, as well as in traumatic and rheumatic lesions of the peripheral nerves, the above tables can profitably be employed. In cases of neuritis, meningitis, etc., they are frequently unreliable, especially in infections or toxic neuritis, but even in these cases complete and partial R. D. may be differentiated. The usual progress of these lesions is so erratic, however, that no correct type or classification can properly be made.

In some cases paralysis is first noted, followed subsequently by the electrical changes; thus in traumatic paralysis, immobility is noted at once, while R. D. follows many days afterwards. In other cases, electrical changes may be perceived in an apparently intact muscle, indicating incipient paralysis or forecasting paresis of a muscle a long time ahead (as in lead-paralysis, cases of spinal paralysis, etc.); then the electrical diagnosis is of great importance.

Frequently the muscles supplied by a paralyzed nerve are not all paralyzed or not all equally affected, evincing various reactions. This is readily understood when one thinks of a slow progressive myogenic process or a lesion affecting the muscles directly, as in trauma. The electrical reactions will, of course, then be purely quantitatively changed.

Partial paralysis is explained with more difficulty when a peripheral nerve or the central organ is affected. The following anatomical facts may assist in comprehending these phenomena:

(1) The spinal motor anterior horns, from which the motor impulse is carried to definite muscles of the body, are not located in a single level of the cord. The cells supplying a single muscle may, in fact, be found in a number of transverse sections.

(2) In one and the same level the motor cells of several muscles are often found represented.

Partial paralysis of the muscles supplied by a nerve in which the former show varied nutritive, functional and electrical reactions are very frequent. It is found especially in diseases

where the primary cells of the peripheral motor neurone are affected, as in spinal or bulbar lesions. Thus, in acute poliomyelitis of children, it frequently happens that in the type affecting the lower extremity, in the region supplied by the peroneal nerves, the tibialis anticus may show complete R. D. while the other muscles show little if any change. This is noted in many other cases of spinal disease.

Electrical Examination of Sensibility of the Skin.—Any metal electrode may be used for this purpose, but one constructed of a bundle of insulated wires inclosed in an insulated sheath the ends of which are filed off until they present a smooth surface is preferable. The faradic current is employed. The inactive electrode is a large sponge well moistened and placed over the sternum. With the metal electrode the surfaces of the two sides are compared.

Symmetrical cutaneous surfaces whose sensibility is normally the same are always examined together and differences in coil distances noted. The functions of the various nerve filaments ending in the skin are many, the sense of touch, the sensation of heat and cold, the appreciation of pain, etc., all residing in minute zones readily covered by the electrode. The variations from normal sensibility must consequently be referred to changes in the nervous elements of the area affected after due comparison with normal variations as tabulated by Erb.

Location of Irritation.	*Primary Sensation.*	*Pain.*
Cheek,	120	200–220
Neck,	120	180–200
Arm,	120	200
Forearm,	115	190
Dorsum of hand,	110	175
Tips of fingers,	90	125
Abdomen,	120	190
Thigh,	115	180
Leg,	110	170
Dorsum of foot,	110	175
Sole of foot,	80	110

This table, of course, is pertinent only to the instrument used. It simply gives the markings, the secondary coil is placed over the primary, and here we do not even know whether these markings represent any special distance, such as millimeters or not. In the faradic batteries in this country this distance is graded in millimeters, and the readings may be taken in millimeters. However, the general relationship represented in this table is quite as good for purposes of comparison as though we did know exactly what they represented, for it is only a comparison of the relationship that we can use.

Increase of electro-cutaneous sensibility has been particulary noted in tetany. Variations of electro-cutaneous sensibility are especially useful in the examinations of claimants for damages in accident cases or applicants for pensions or sick funds. In suspected fraud the same points may be tested at different times and marked variations in the recorded sensibility will assist in uncovering deception.

There are many cases of hysterical anæsthesia, which are unconscious to the prick of a pin, but no matter how complete the apparent anæsthesia may be, if it is of hysterical origin, a strong faradic current applied by means of the wire brush electrode, will produce so much pain that the patient cannot resist crying out. Therefore, an anæsthesia in which the faradic brush is not felt, providing, of course, the current be of sufficient strength, is not hysterical, but is due to some organic change.

According to Sperling, the galvanic current has also been employed for the examination of cutaneous sensibility and pain. The assumption that the galvanic current, by virtue of its accurate measurement, is better adapted for this work is disproved in practice, as the painful corrosions and burns produced on the skin by the application of moderately strong currents, by means of metallic electrodes, precluded an extensive employment of this method.

By the application of moist electrodes the appearance of the primary sensibility of the skin may be ascertained through comparison in some cases. In other instances, as in diseases of the vertebræ and the spinal cord, it is possible, by means of

the application of the large, moist cathode over the suspected diseased parts with a weak or moderate current (up to 5 ma.) to determine or detect sensitiveness of the more internal parts, a symptom which may be of value diagnostically or therapeutically.

Duchenne's "electro-muscular sensibility" is at present disregarded by many practitioners. It is independent of cutaneous sensibility, which must therefore be eliminated as much as possible so as to secure correct observation of the electro-muscular sensibility. Therefore cases where the sensation of the skin is more or less impaired or diminished, as in anæsthesia, are most appropriate for the examination. Duchenne lays great stress on the importance of electro-muscular sensibility, which is produced when the irritation of a mixed or purely motor nerve causes a sensation of "drawing together" in the muscles supplied by it, analogous to the sensation of strength or weakness experienced in exercised muscles.

Vigouroux and others have called attention to the variations in the resistance of the body to the electric current in different diseases. The methods of examination are complicated and can only be applied after much practice, the precise diagnostic value being, at present, not well appreciated. The diseases in which the resistance is increased are:

Hysteria,
Epilepsy,
Various psychoses,
Scleroderma (most marked),
Muscular atrophy,
Hemiplegia and paraplegia,
Infantile paralysis,
and most fevers.

The chief lesion in which diminution of resistance is noted is Basedow's disease (exophthalmic goitre) in which it is quite markedly lessened.

The pathological condition of the tissues in these stated conditions gives a clue to the cause for the change in resistance. Thus in Basedow's disease there is marked activity of

capillary and arterial circulation, also a marked increase in secretion of the sudoriferous and sebaceous glands, permitting ready permeation by the electric current; while inversely, in atrophy, scleroderma, hemiplegia, etc., nutrition is impaired with consequent diminution of fluidity of the tissues and resultant increased resistance to the current. In a general way, it may therefore be deduced, that, when these various lesions tend to recovery, they will gradually approach the normal resistance of the body and inversely as the resistance remains augmented, improvement cannot be noted.

Electro-Diagnosis in Gynæcology.—The large number of applications of electricity that have been made in gynæcology have developed, to a degree, a series of indications and contra-indications which are not only useful as a guide in the administration of the electric current itself, but also as a guide to diagnosis, and may, if employed, do away with the exploratory incisions that are so frequently made.

First the Faradic Current.—The faradic current has, when rightly administered, great power; in fact almost universally it will relieve those hysterical neuralgic pains of the ovaries which are so common. This relief at first may continue only for a short time, but will, after a few treatments, be complete. On the other hand, if there is an inflammation or other organic changes in the ovaries, the relief produced by the faradic current will only be temporary, lasting a few minutes, and will not increase after each treatment. This teaches us not only the indications of the faradic current, but also the nature of the disease.

Second, the Application of Galvanism.—It will be found that patients are very tolerant to the application of the galvanic current to the endometrium if there is no disease of the appendages, the ovaries and Fallopian tubes. There is perhaps one exception to this: a small cyst on an ovary. If, therefore, an application of a strong current, say 100 milliamperes of galvanism, to the interior of the uterus is well borne and not followed by febrile reaction or aggravation of the symptoms you may consider that the appendages are in good condition;

but if you find that the uterus is very sensitive and the application of 50 or more milliamperes is followed by febrile reaction and other unfavorable symptoms there is trouble with the appendages. If the febrile reaction is particularly great it indicates a collection of pus in the appendages, such as a pyosalpinx. If, however, the reaction decreases after two or three applications, it indicates that the inflammation of the appendages is disappearing.

Electro-Diagnosis of Death.—In cases where doubt as to death exists, the diminished irritability of the muscles, and later the entire subsidence of irritability after one and a half to three hours, will be conclusive proof of the departure of life.

SECTION FIVE.

Organic Electrology.*

Electro-Physiology.—The territory of Electro-Physiology naturally covers all organic phenomena in which electricity plays an essential or accessory part, but its actual boundaries are as yet undrawn, as theory cannot foreshadow them, and as no certainty exists that our instrumental means of detecting either electrical currents or potential have already reached their utmost perfection.

Yet with a delicate reflection galvanometer built on the Weston principle and with non-polarizable electrodes such as those of Du Bois-Reymond, one can measure the minimal currents experimentally produced by but a few muscle cells or nerve fibres: and this very experience, together with entirely similar observations on plants and the well known properties of galvanic elements lead us to hold, that all chemical action is accompanied by the generation of electricity, which merely requires a prevailing direction in the *arrangement* of the substances or of their parts to each other to manifest itself externally.

As in the case of a galvanic element, the current not only acts outwardly but also effects an internal alteration, which can be measured in the form of an increasing polarization of its plates, so it is probable that in tissue electricity, generated as in muscle and nerve cells and endings, acts inwardly and, so soon as special polar arrangements are present as in nerve

---

* This section, up to Electrolysis, is written by W. Y. Cowl, M D., of Berlin, Germany.

and muscle fibres, receives a set direction, whether as a current or as a wave of heightened polarity.

The prevalence of electricity in all organic processes is assured by innumerable facts accumulated by the systematic pursuit of *chemical physics* during the past two decades. Chief amongst them is the dissociation of the atoms in the molecules of all substances capable of electrolysis when their watery solutions,—which are almost alone electrolizable—become sufficiently diluted. In the dissociated state they are known as ions and possess qualities different to a greater or less extent from those of the fixed atoms. All chemical reactions take place by means of ions, as a rule in water or in a glow of heat. The most active ions are those of acids, alkalis and salts.

When becoming passive on entering as part of a molecule they give up electricity, which is usually converted at once into heat as in chemical reactions, *e. g.*, the neutralization of acids. On the other hand, they give evidence on their formation of an electric state, whilst non-ionized substance in an electric state may resist their action. Zinc negatively charged will not be acted on by chlorhydric acid its strongest solvent.

But beyond the results of such physical experiments which have been carried out with such extraordinary success, the field of observation with new methods and guided by new principles, is opening in physiology,—in truth upon an electric basis,—which seems destined within the coming decade to so clarify, extend and systematize our knowledge of the processes of organic nature as to render the infinite labors of the past century chiefly a treasure for those undertaking new researches and not wishing to stumble over the pitfall of some existing fact.

A considerable literature has indeed already accumulated on the "border of the twentieth and twenty-first centuries" chiefly however by non-physiologists.

Not the least effect of the junction of chemistry and physics, including electrology, is the coming change in nomenclature, commensurate with the advance of well-grounded theory,

which we have not hesitated to incorporate in the following exposition of the fundamental phenomena common to electrophysiology, pathology and therapy.

That arrangement of different substances, which we have above designated as essential for the outward flow of electricity from them, is characterized by the term *polarity*. Typical of such a polarity is the arrangement zinc, acid, copper, in a Daniell cell but as Helmholtz showed it may be far simpler, since two superimposed solutions of the same salt of different strength also yield a constant potential, form indeed a simple galvanic element, whilst Daniell's and most other common forms of cell with superior potential are compound.

The production of electricity by tissue is doubtless of these two kinds, by concentration—and by reaction—elements but of inordinarily smaller potential. The parallel arrangements in muscle and nerve, fibrillar, tubular and discoid, suffice to sum up their electric power. In the case of muscle the transverse striation must be viewed as a polarity vastly multiplied in a single direction. Since Kuhne's remarkable observation of its quick re-establishment after the chance passageof a parasite throughout the semifluid contents of a muscle fibre the polar arrangement of its elements have been regarded as labile and automatic.

One effect of this multiplied polarity is the higher potential, which muscle evinces above that of nerve.

The maximum of 0.08–0.1 volt, which a muscle under favorable conditions of experiment will show, is doubtless in part due to a summation of the potentials of succeeding striated elements, since it is less in shorter muscles.

The *current* on the other hand, which any muscle will develop, depends necessarily on the resistance offered by the muscle to its passage and this resistance varies with its length and inversely with its cross-section. On shortening a piece of muscle yielding a current the potential between the electrodes will, *cœteribus paribus*, be diminished although the current, owing to the diminution in length and consequently in resist-

ance, may increase and does so, as a rule, for the reason that while the diminution in resistance is simply proportional to the length, the potential depends in cut muscle chiefly on active local processes occasioned by the injury. It is well established, moreover, that an entirely uninjured muscle does not, when at rest, reveal the polarity of its elements. It yields no currents. But since the electric phenomena of muscular action are simply exaggerated by a cross-cut or other injury these measures have been continuously and successfully employed for study and demonstration.

Since the electric phenomena or non-striated muscle as well as its irritability toward all excitants but cold are far less considerable than those of striated muscle, electrological observation and experiment have confined themselves chiefly to the latter, which indeed by reason of its demarcated, loosely connected exterior, as well as the length and regular disposition of its fibres and their circumscribed connection with bony points especially fit it for exact observation. The fortunate circumstances, moreover, that the isolated muscle of the common amphibians has been shown to be essentially similar to that of the homothermous vertebrate, has allowed of great advances in knowledge of the mechano- and electro-physiology of muscle.

The observations of a century by Galvani, Volta, Humboldt, Matteucci, Du Bois-Reymond, Pflüger, Hermannn and many others have circumscribed by analytical work on isolated material the extrinsic phenomena and conditions of animal electricity and prepared the ground for the moment when physics shall have determined the intrinsic nature of electric force itself. But even at present on the ground of researches, time-honored and recent, one can maintain that nerve-conduction and muscular excitation are carried on directly by electricity; for on the one hand since the observations and theoretical conclusions of Faraday have become fully recognized, chiefly by Maxwell, Hertz and others, including investigators in physical chemistry, the transport of electricity in watery solutions or in semi-solids such as tissue, in short in

electrolytes, is known to proceed with and subsist in electrolysis or electrolytic polarization short of gas-formation and on the other hand the velocity of conduction in nerve itself or in a physical model of nerve has been shown to be identical with that of polarization of nerve or electrotonus proceeding from a point of electrical excitation, whilst, furthermore, however long a nerve may continuously conduct it does not tire in action nor spend material and energy like a muscle or a galvanic cell.

The burden of proof now lies on those who maintain that the nervous impulse is something else than electricity, for of all known forces it is both the most susceptible of isolation and conduction and the least consuming of energy in employment.

Accepting this point as practically settled, it is unnecessary to recall the details of the researches which have led to this result. But from the established facts have proceeded those generalizations respecting the electrical excitation of muscle and nerve, which serve as part of the fundament of electrology and neurology. Chief amongst them are those of Du Bois-Reymond and of Pflüger.

The law of excitation enunciated by the former is contained in the statement, that what electrically excites in nerve and muscle is not the strength but the change in strength of current flowing through them, and that the degree of excitation increases with the rate as well as the amount of change, whether starting from zero or above it. Recent investigation especially with the capillary electrometer, together with the help of kinematic photography of its movements have completed the probability that the natural waves of current in nerve excite in like manner with those of artificial origin.

Pflüger's generalization concerns in the first place the phenomena of electrotonus or electrolytic polarization of nerve, which owing to their functional susceptibility to electricity doubtless concerns the conductive elements.

It has indeed been sufficiently established by Hermann that both nerve and muscle are very susceptible of polarization, and

also possess the power of most rapid depolarization, the nerve far excelling in each respect.

The simplest expression of Pflüger's observations is the statement that a stretch of nerve traversed by a current evinces increased excitability at and to both sides of the cathode and a correspondingly diminished excitability on and about the anode, in short catelectrotonus and anelectrotonus. Between the electrodes, as well as beyond them, lie unaffected points from which the electrotonus increases in intensity up to each pole. The midpoint of indifference is centrally located when medium currents are employed, but advances toward the cathode with a stronger and retreats toward the anode with a weaker current.

Furthermore, upon breaking the current polarization, already effected, occasions a reversed electrotonus, *i. e.*, diminished excitability on and about the cathode and an increased excitability about the anode lasting for a portion of a second.

A secondary effect of electrotonus in addition to the altered excitability is a diminution in the conductivity of the nerve, which with the employment of strong currents can prevent the passage of an adventitious excitation exerted beyond the electrotonic nerve section even for a short time after breaking the current.

When the electrodes are not directly applied to the isolated nerve but with intervening tissue, for instance clinically, as in the living organism the effects are not the same, as was found by Erb, but are complicated, as was shown by Helmholtz, in that the current crosses the nerve diagonally either at one or both poles according to the position of the electrodes and thus produce at each pole both anelectrotonous and catelectrotonus.

The fundamental phenomena concerning the *effects* of electrotonus on excitation find their typical expression in Pflüger's *law of nervous excitability* (Zuckungsgesetz), which is given in the facts that I. *weak currents*, whether proximally or distally directed, produce contraction only on making not on breaking the current, since the catelectrotonus in these cases

is stronger than the anelectrotonus, II. all currents of *medium* strength excite both on the make and on the break, III. *strong currents*, owing to the above mentioned impairment of conductivity, *a.* in the anelectrotonic section during the current, *b.* in the catelectrotonic section after the current, only excite when proximally directed on breaking when distally directed on making the current in both cases at the electrode nearer to the muscle, in accordance with the rule, that the excitation on the rise of current takes place at the cathode with its fall at the anode.

The ground facts of Pflüger's law furnish an epitome of the action of electricity on nerve and muscle, that has not yet been fully realized. Above all else the remarkable circumstance that on the break current the condition of diminished excitation at the anode reverses to one of increased excitability. Notwithstanding the presence of the same products electrolytic polarization, of the same ions, in this case anions, as just previously during the flow of current, the reversed functional condition obtains. This reversal is, therefore, quite certainly connected with the polarization currents, or depolarization of contrary direction to the polarizing current, which, on the cessation of the latter, immediately set in within the nerve, as a mass of experiment, chiefly by Grützner and Tigerstedt, goes to show.

Apparently unreconcilable explanation given is the excitation that may result from a partial fall of a polarizing current in a nerve. Before considering special researches directed to the entire question of excitation upon a fall of current, we would note, respecting this experiment, the manifest agreement with the law of excitation of Du Bois-Reymond, and that the excitation alone depends upon the electrical processes in the nerve at the *moment* of the fall of the current. The highly polarized nerve may at this instant well occasion a current within itself overbearing for the first thousandth of a second the galvanic flow. Furthermore, for metals, which like nerve do not oxidize on polarization and are therefore highly polarizable, it is certain that the potential of a polari-

zation with a weak galvanic current may equal that of this itself and stop the flow. For nerve it is therefore highly probable, that in the special cases mentioned a momentary intrinsic change in the direction of the electrolysis (*i. e.*, within the tissue) actually occurs, despite the persistence of a greater extrinsic potential at the electrodes. As a matter of general experience, it is difficult with fresh nerves to secure an excitation not only on diminishing but also on breaking a current. A remarkable fact in this connection is, that Du Bois-Reymond ventured the opinion nearly half a century since, that excitation is probably nothing more than the beginning of electrolysis.

With reference to excitation upon a partial fall of current as well as in the other cases above specified under Pflüger's law of contraction, it remains to add, that an excitation of a nerve, sufficient to occasion contraction of a muscle enervated by it, only results, when in accordance with the law of excitation the change in current strength, whether between zero or an already present flow and a higher intensity, is sufficiently rapid. A current carrying any amount of energy can "sneak in and out" (*ein- und aus-schleichen*) without occasioning a muscular contraction.

But if there is no adequate evidence that a fall of current excites otherwise than by the rise of a polarization current, it is evident that we may say that excitation is due alone to a rise of current of sufficiently rapid rate.

An experimental proof of this position is nevertheless highly desirable. Respecting such it is obvious, that if upon the sudden fall of a current of short duration the polarization already effected has not yet reached excitatory power, since it must always remain less than the potential polarizing current it cannot add to the excitation by this current, however produced, whether by its rise, its fall or both: and on the other hand, if a current on its fall excites only by means of the polarization already effected, then recursively the fall of a current of short duration having produced as yet no considerable polarization will effect no excitation. But a further con-

sequence results from the increased excitation upon increased suddenness of change in current strength predicated by Du Bois-Reymond's law that when the fall of such a current be of no excitatory power it cannot augment any excitation due to the rise of current, and will therefore occasion no difference in the amount of excitation, whether sudden or gradual.

These considerations, together with the fact that the make current from the secondary coil of an induction machine supplied with a solid iron core has an unusual length of flow beside a gradual rise and fall, led the author to the following briefly detailed arrangement and results of experiment on the customary object, the sciatic and gastrocnemius of rana esculenta.*

A Du Bois-Reymond spring myograph was furnished with a nose piece on the travelling frame so finely adjustable by a micrometer screw as to permit of constant differences of 0.0004 sec. between the moments of two current breaks.

By suitable connections of the circuits of a standard induction machine—having a long slide and a galvanometric scale—with three commutators it was possible at first to determine by means of a delicate reflecting galvanometer, the succeeding intensities of a current from beginning to end of its flow as well as its duration of nearly 0.01 sec. and furthermore after shunting the nerve in place of the galvanometer to induce contractions of the muscle—traced by itself on the smoked glass plate of the myograph—by transmitting to it currents in the five following forms: I. the whole current; II. the natural rise and an instantaneous fall at the acme; III. an instantaneous rise at the acme with the natural fall; IV. an instantaneous rise and fall at beginning and end of the acme, distant from each other about 0.001 of a second; V. the current II followed by the current III with an interval equal to the length of IV. The results were, *a.* that no difference in the amount of excitation by the currents I and II was to be detected; *b.* that the excitation by I and II was far less than

*Vide Verbandlungen der Varsammlung deutscher Naturforscher und Ærtzte. Wien, 1894.

by the other currents; *c.* that no difference in the excitation by III and IV existed; *d.* that the difference between I and II over against III and IV was as 1:8, measured by parity of effect in special experiments with currents of different original strength and by comparison with a special galvanometric scale on the induction machine; *e.* that V was greater than IV and far greater than I.

It should be added that the currents III and IV in the above experiments which yielded a like excitation, resembled the induction currents upon breaking the primary circuit, in that they have a sudden rise and that their relation in strength to I and II with gradual rise was 8:1 or the same as that between the excitatory strength of make and break shocks.

From the foregoing it is clear that a sudden fall of a just risen current of medium strength yields no excitation. We may therefore further conclude, that polarization has not taken place to any considerable degree and conform in consequence foregoing statement, that experimental excitation in general is only due to a rise of current in tissue of sufficient strength and rate, whether due to an outer or an inner potential.

A point which is not yet definitely decided in electrophysiology is the frequency per second with which induction currents still continue to excite. It is now known that the technical alternating current of very high frequency, which like all dynamo currents is generated by induction occasions no pain nor violent muscular contraction, but the border line between the currents of lesser frequency that excite and those of higher that do not is still unsettled. It is however experimentally maintained, that a frequency of more than 2000 per second does not excite, and that an apparent excitation by higher rates is due to irregularities in the strength of the individual currents, which, we will add, may be either rhythmic or arhythmic. Personal experience with the Tesla current, which may be characterized as faradic-franklinic leads the author to refer its excitation of the sensor nerves to the rhythm of the currents from the secondary coil of the Rhumkorff whilst

the occasional muscular contractions may be attributed to shocks of unusual strength.

As determined by Feddersen in 1861 the discharges from a single franklinic plate as a condensator for the alternating induction current and for this purpose connected with the ends of a secondary induction coil and a short spark stretch, which is the fundamental arrangement of the Tesla-D'Arsonval apparatus, alternate at intervals of some millionths of a second.

This exceedingly short interval is doubtless the reason for the non-excitation of the motor nerves by the Tesla current. The excitation of the sensor nerves by all forms of current employed in medicine may be regarded as still unexplained, but certainly due to a finer sensibility.

To arrive at an intelligent comparison of the excitatory effects of different forms of current on nerve, medullated and non-medullated, and on muscle, striated and non-striated, it is obviously necessary to possess approximate measurements or estimations of the current dimensions, but these are far from being all attained. It is indeed an easy matter to measure any constant current or applied potential and to calculate therefrom the resistance present, whether intrinsic or partly due to polarization.

With induced currents it is otherwise since a galvanometer is for them only an index. Even when the relation of the pause to the current interval is known or fixed, the energy developed in both coils varies with all but lesser frequencies of current interruption and with every change in resistance in the secondary circuit. By the method above noted for the comparison of different induction currents with a widely sliding secondary coil and a galvanometric scale precise determinations of the excitatory strength of *single* induction currents of any strength can be effected through the employment of measured shunts for unbearable intensities ; and the same may be said respecting franklinic discharges or the shocks of the South American torpedo, electric eels, etc. When coming to the Tesla current however both these means and calcu-

lations fail and it must be left to the future to decide whether the apparent probability that the potential amounts to millions of volts is to be verified.

In a series of researches* undertaken by the author to ascertain whether the marked sensation of warmth in the cutis upon the application of the Tesla current was largely transformed electric energy and not chiefly due to mere sensation and the dilatation of the blood-vessels usually occurring, the remarkable fact was disclosed, that the Tesla current sent through a resistance equal to that from palm to palm of an adult and composed of normal saline solution ($8NaC1+1000H_2O$) in a glass tube repeatedly occasioned within half a minute a rise of temperature of 26° C. over against a rise of 1° C. upon the employment of the original secondary currents of the inductor alone, having in air a spark length of 20 c.m. with an indicated primary current of 1½ ampere (at the moment of the break probably 4 A.). Upon a repetition of this experiment with a long tube and thermometers at the middle and both ends it was furthermore found that the rise of temperature is the same at each of the two electrodes and that at the midpoint between them there is also a rise to a considerable fraction of the height reached at the two ends.

Since the Tesla current cannot be stronger and must be weaker than the induction currents from which it arises, it is evident that the latter are transformed into heat in the electrolytic resistance in far lesser measure than the former. This may be occasioned by more than one circumstance but is certainly due to a continual polarization and depolarization at intervals of a millionth of a second and to an amount proportional to the enormous potential of each discharge. That the electrolysis which this polarization is synonymous with exerts its energy not only on the surface but also on the interior of the electrolyte was shown by the rise of temperature in the central thermometer in the above experiment.

Respecting the detailed results with alternating currents as

* Vide Deutsche Medicinische Wochenschrift, 1901.

well as the behavior of other forms of current employed on tissue it is to beremembered, that the various questions concerning the transmission of electricity in metals, watery solutions, and gases are far from being all answered. Those for us most pressing are the dimensions of the electric waves in metals and electrolytic substances and their actual velocities.

A phenomenon pertinent to excitation to the measurement of exciting currents and to the transport and transformation of electric energy in the organism is one source of error in experiment which has hitherto received insufficient attention and not yet been brought into connection with allied observations of more recent date, namely a *unipolar aberration* of current into the organism or through it into the surroundings or the earth. A simple and evident means of obviating its misleading effects respecting the part actually excited, especially when a nerve deep in an incision be in question, was recommended and employed by this observer and others, consisting in "grounding" one of the electrodes, for instance by a back connection with a gas or water service pipe. The earth as an infinite condensator then diverted the unipolar charge. In recent years Gaertner observed, that when a large organism is intercalated in a circuit with a galvanometer and the secondary coil of an induction machine a make induction shock no longer yields the same amount of deflection of the needle as the break current but that the latter greatly predominates. Hoorweg then found that a carbon rheostat had the same property and that this substance as well as the organism acted as a condensator, taking up and transmitting or transforming larger amounts of electric energy under a higher than under a lower potential. The facts detailed have, however, still another obvious bearing, namely, that the amount of current or energy entering from an electrode will at the first instant of its flow vary according to the size of the organism, and that it is indeed a question how far any instrument can give an adequate idea of the amount of current at its first and determinative moment respecting excitation. For the galvanic current it is well established that an enormous

and very rapid reduction of resistance occurs in the cutis at the beginning of current flow, which is chiefly due to cataphoric moistening of the epidermis.

To avoid the indicated unadaptability for the purpose of comparison of excitatory power, of physiological and pathological excitation, which is inherent in simple physical measurements by instruments however precise, it is obviously necessary in the first place to determine the *relative* excitatory power of common forms of current.

As a beginning in this direction, the author published* together with a description of a method devised and used for such purpose, the results of a comparison of the physiologica

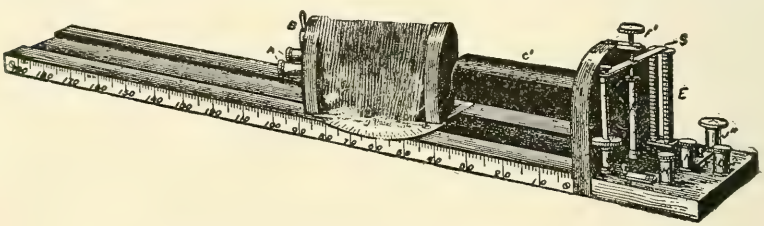


FIG. LXXI. Standard Du Bois-Reymond Coil.

strength, respecting the excitation of sensor nerves (palm of the hand), of the two different induction currents obtained from a standard induction machine.

It was found that with the employment as usual of an electro-magnetic core of some hundred pieces of iron wire, the break current was eight times stronger than that on the make, or without the core three times stronger.

For such determinations induction currents are especially recommendable since they produce no unnecessary electrolysis after the excitation is affected, so that the excitability of the tissue, nerve or muscle, remains quite unchanged. Since with the method alluded to it is also without difficulty possible to consummate a comparison between the galvanic, franklinic, faradaic and Tesla currents, we add it in brief detail. An in-

* Vide: The construction, action and employment of the Du Bois-Reymond induction machine as a standard source of faradic current. Journal of Electro-therapeutics, VII and VIII, 1891.

duction machine with sliding coil and a scale of current which unless great strength of primary current are employed must be galvanometrically determined up to the distance of the coils from each other at which the law of induction, that the current strength diminishes as the square of the distance obtains its full sway, whence the coils act only as points toward each other. A constant source of current, a Becquerell-Daniell cell, an accumulator + 5–10 Ohm resistance or a circuit with a street current and an incandescent lamp.

Two commutators so connected and bound together as to exchange the primary and secondary currents to be compared simultaneously. A double shunt to take the unwished for currents.

With these means it is possible to rapidly and repeatedly excite first by one and immediately thereupon by the other of two heterogeneous currents, one of which has a known strength on the scale of the induction machine. It need scarcely be added, that both nerve and muscle are exceedingly sensitive on such comparisons, whether isolated or in the intact organism.

Cataphoresis.—The transport of water by the electric current traversing an electrolyte, which is known under the name of cataphoresis, and as above noted prevents the measurement of the exciting strength of the galvanic current, is exemplified by the unequal height of the columns of water in a U tube through which a current is sent, standing higher at the cathode.

This phenomenon, which beyond all question is of a capillary nature, *i. e.*, connected with a change in surface tension which in all fluids represents a very considerable force, has been likewise held responsible for the transport of other substances into the organism at the anode; but it is now known that this section is only an example of electrolytic transport, taking place through the splitting of a substance in solution at the electrodes, the electro-positive kations of which will be introduced at the anode and the electro-negative anions at the cathode from each of which they flee toward the opposite pole.

When the anode alone is furnished with a solution of the

substance, the kations of which wander into the organism, the anions will collect about the anode itself.

Electrolytic transport of substance in the form of ions is therefore the essence of what has hitherto been known as cataphoresis, a name given it by Du Bois-Reymond but not accepted by all lexicographers since that time.

The prospect for exact and careful observation and eventually for therapy by the application of this newly recognized principle is at present apparently unbounded, but will doubtless soon be restricted by not neglecting previous experience.

To characterize the possibilities of electrolytic transport by ann istance, we will note that from a solution of sulphate of

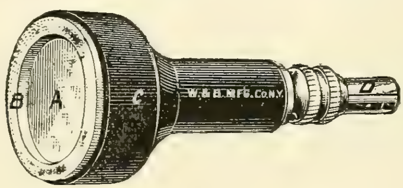


FIG. LXXII. Cataphoric Electrode.

morphia the narcotic base will be introduced at the anode, wandering from it toward the cathode, but owing to the great size of its molecure at so slow a rate as to render its progress scarcely discernible.

As had indeed been empirically found in experiments, supposedly on cataphoresis, simply binary compounds are best adapted to the introduction of a desired component, for instance potassium iodide. Under the new point of view the mercurial iodides naturally come into consideration.

It is also now well known that even amongst common binary substances in solution such as the haloid salts, the respective ions wander with different rapidity. Only potassium chloride possesses in each of its components atoms which, when the solution is sufficiently diluted, become partly or with greater dilution wholly resolved and converted into ions ready to wander electrolytically or to engage in chemical reaction. Natrium chloride in the proportion contained in the blood, lymph, etc., or in a normal saline solution is approxi-

mately dissociated into ions which have a moderately different rapidity of motion.

Water and all acids which give off hydrogen at kations act with especial destructivity to tissue at and near the negative pole since hydrogen has a so exceedingly great rapidity of electrolytic transmission.

In this case as with the far superior rapidity of diffusion of the molecules of hydrogen over all other gases the explanation resides in the small size of its atoms as indicated by its atomic weight.

Next to hydrogen stands hydroxyl (HO) which is an anion arising on the electrolysis of water and all alkalies as noted in the following table of ionic rapidities, determined by Kahbrausch with the help of the Bell telephone.

Apparently in contradiction with these determinations is the law of Faraday that in electrolysis the elements deposited at the anode are always chemically equivalent to those deposited at the cathode; but Hittorf showed, many years before his labors were recognized, that in the *neighborhood* of the electrodes there was a chemical inequality in the amount of anions and kations accumulated, *i. e.*, when other substances than potassium chloride were subjected to electrolysis, even if no gas were developed. And upon the measurement of these inequalities are chiefly based our knowledge of the properties of ions in contradistinction to simple atoms within a molecule.

TABLE OF RELATIVE VELOCITIES OF ELECTROLYZED IONS.

(Determined for a potential of one Volt per centimeter.) (The figures in parentheses are less positive than those without such; they refer to a singe equivalence.)

H	K	Na	Li	NH_4	Ag	½Ba	½Sr	½Ca	½Mg	½Zn	½Cu
300	60	41	33	60	52	(52)	(50)	(46)	(46)	(46)	(48)
OH	Cl	Br	I	NO_3	ClO_3	CHO_2	$C_2H_3O_2$	½SO_4			
165	63	62	62	58	52	41	(33)	(66)			

A practical point in the use of current has been discerned by Friedlænder,* who to offset and counteract the destructive action of *anions* and *kations* at the poles, uses an *alkaline* preferably of sodium monocarbonate, as the *anode* and *acid* solution, preferably chlorhydric acid, as the *cathode*, with the result that inordinately strong as well as long lasting currents can be borne without escharotic effects.

During the flow of current "carbonic acid is given off at the anode" and hydrogen at the cathode, evidently driven out of their chemical combinations by the anions and kations from the tissue, which finding the chance give up their electric state as current bearing ions to form in part new molecules with the ions of sodium and chlorine into which both enter as simple atoms, in part to remain as ions in equilibrium with those of Na and Cl in proportion to the dilution of the solution.

It will not perhaps be necessary to at once discard zinc and other metallic electrodes because they "oxydize," but for this very reason retain them for many purposes as the oxydation in reality consummates a depolarization† of entirely the same character as that effected by sodium carbonate at the anode, which yields up carbon dioxide as a gas to combine with the oxygen anions to sodium oxide (and with water to the hydrate).

The formation of carbonic acid is simply impossible since hydrogen in large excess were requisite and in such excess only conceivable as a kation at the *cathode*.

It is probable that reducing agents perhaps formaldehyde (formalin) and non-acid oxydizing agents, would also subserve the purpose of polar satiation of nascent ions.

Special Physiology of Muscles.—Muscle finds its prototype in the amœba a unicellular organism composed essentially of *albuminous substance*, stretching out portions of its cell body in

* Das Faradaysche Gesetz in der Elektrotherapie. Zeitschrift fuer klinische Medicin. 1900.

† Vide W. Cowl, Versucheueber schwach polarisirbare Metallelktroden-Engelmann's Archiv fuer Physiologie. 1899. p. 326.

response to differences in its surroundings, for instance, diminished resistance, heat, light, weak alkali, electricity, etc., locally acting.

In higher forms of life the contractile substance forms sheaths and contracts in a plane in several or but two opposite directions like the striated muscle, which is distributed mainly in the cylindrical or spindle form.

Flying insects because of the rapid motions of their wings possess even more highly developed striated muscles than man. In all slowly moving non-vertebrate organisms the muscles are chiefly non-striated and seldom disposed in a single direction, but where parallel in any number they evince electrical phenomena which are, however, much less marked for the reason that with the absence of transverse striation there is no great summation of potential within them.

Non-striated muscle is, however, well adapted to long continued contraction with a minimum expenditure of energy, and is therefore found in the walls of the intestine, of the blood vessels, of ducts in the skin and mucous membrane, ureter, uterus, in the iris as a rule, in the ciliary muscle, etc., and is involuntary. In birds of prey the M. iridis is striated and voluntary in certain fishes that of the intestine.

It is unquestionable that striated muscle is a higher development of the non-striated and that the former may, as in the weak electric fishes of the Nile, become converted into nervous tissue.

The contraction of non-striated muscle in the walls of cavities is peristaltic and nearly 100 times slower than that of striated fibres. Differently from the latter cold, as well s aa continued constant current, cause it to contract whereby its substance does not assume an acid reaction like striated muscle. Its chemical constituents are simpler.

In the warm-blooded animal and in summer in amphibians it responds to energetic induction currents, but far stronger than requisite to occasion the contraction of striated muscle. Non-striated muscle fibres have in man a length of 100–200 u. and a breadth of 4–6 u. on the average, but may reach 600x22

u. = 0.01329 m.m. Striated fibres reveal lengths up to 12 centimeters and a diameter of 10–100 u. Each fibre is a multinuclear cell containing reserve material within a sheath of striated substance, that on being subjected to various preservative treatment breaks up into fibrile or into Bowman's discs. The planes of breakage are those which in the intact fibre are filled with the less consistent sarcoplasma.

A muscle fibre may receive in its course several nerve fibres which penetrate to the striated substance beneath the sarcolemma or enclosing sheath, and divide into several fibrils that branch out upon the muscle substance.

Chemically the muscle fibre contains a reserve of glycogen a sugar-like substance of high molecular weight which furnishes energy by splitting into substances with smaller molecules and by internal oxydation. It is also probable that special fats and albumens are stored and used by muscle. The substance of muscle is avid of oxygen and alkaline. In action it temporarily accumulates sarcolactic and gives off carbonic acid. It contains 75% of water.

A muscle is highly elastic longitudinally, chiefly in consequence of the connective tissue sheath of the fibres, since their contents are semi-fluid. A weight which it cannot lift will, however, stretch it more when at rest than when in action. As long since shown by Schwann it pulls with greater energy when extended than when nearing its fullest contraction.

It contracts unweighted about 20% of its length and pulls uncontracted according to the size of its cross-section from 1-10 kilograms per quadrat centimeter in different individuals. This force may be considered ultimately as an electrical one.

Muscle chiefly supplies animal warmth, whether by evident or non-evident action. It makes use of 30–40% of the energy of food taken. The steam engine 10% of that in coal. The constant muscular tonus of the living individual doubtless keeps up a condition of electric polarity in muscle substantially as maintained by Du Bois-Reymond.

Mechanical excitation of muscle follows a light transverse percussion whilst no non-injurious amount of stretching, even the most sudden, will excite contraction.

It is probable that this difference resides therein, that in the one case a local impression may spread as a wave of contraction, whereas in the other no response in the form of a wave can well occur.

Warmth occasions a coagulation and consequent contraction of muscle varying with the temperature according to the animal; in the amphibian at about 45° C. It is similar to rigor mortis. A striated muscle cooled contracts slowly, and forcibly, when warmed quickly but transiently in response to an induction shock. This jerk follows about 0.01 sec. after the electric excitation, and lasts nearly 0.1 sec. A continued induction current occasions about double the amount of contraction as long as it lasts, whether applied directly to the muscle or to its nerve.

When a muscle is excited at one point, as usually in experiment, a wave of contraction starts at the same and proceeds until the entire muscle is in contraction. Even when there has been but a single excitation, a certain time regulated by the temperature and the freshness of the muscle, always elapses before a relaxation begins at the first point of contraction to proceed like a wave of rising energy to the other end.

In excitation of a muscle through the nerve no such wave is to be observed, but since the nerve fibrils enter the muscle fibres at all points except near and at their ends, it is highly probable that just such waves of contraction take place in each muscle fibre and occurring equally in all parts of the muscle except the ends, which are usually stoutened by aponeuroses and tendon, serve to prevent tearing of the connective tissue sheaths of still uncontracted portions of the muscle, where the muscular substance have not yet taken up the strain.

The individual contractions fuse thereby to a tetanus as may be seen on gradually increasing the frequency of the induction currents from 5 to about 20 per second. With the same non-maximal strength of current the amount of contraction increases increasing the frequency continuously up to about 100 per second.

With the galvanic current as indeed with the faradic, when

of enormous frequency, a contraction takes place only at the initial rise and final fall except when the current be inconstant with sudden variations. The contraction wave in human muscle proceeds at the rate of 10 meters per second.

The excitability of a muscle differs in response to a great variety of circumstances, it increases with the temperature—in the amphibian from 0° to 30° C.—when a continuous induction current insufficient of itself to occasion contraction, is traversing the muscle, or when the muscular substance is rendered slightly more alkaline. It diminishes with cold, with the length of time after a foregoing excitation measured in minutes, and with acidity of the muscular substance.

The accumulation of waste products in the muscle substance, which following the general physiological rule act as poison to it, occasion phenomena of exhaustion, comprehended in the main by a diminution in the height and an increase in the length of single contractions in response to individual induction shocks. A similar condition is the muscular cramp from prolonged or ill prepared for exertion in cold water.

The static electrical condition of muscle is revealed by it, when after cross-section at some point electrodes leading off to a sensitive reflecting galvanometer are placed, the one at or near the cut the other on or near the middle of the muscle. A potential approaching 0.1 volt then makes itself evident by a current which goes *in the mascle* from cross-section to equator. On exciting the muscle to contraction this current greatly diminishes for a moment in amount undergoes a negative variation that passes along the muscle from the point of excitation on as a wave. If the nerve of another muscle be laid lengthwise on the former, both will contract in consequence of an excitation of the nerve by the negative variation or current of action in the cut muscle.

Whichever of these designations be theoretically employed, it is evident that what excites the nerve is a sudden change of current intensity in accordance with the law of excitation detailed in the foregoing chapter. When the nerve be let fall on the current giving muscle when at rest, a secondary contraction will also occur.

On the application of induction currents of 20 per second, there will be a continuous secondary tetanus of the muscle excited by its nerve.

The muscle current is diminished by cold and increased by heat as well as by other agents, such as creosote which cause a rapid death of muscular substance. As muscle fibres are not isolated or at least not markedly so it is evident, that a muscle current led off through a galvanometer is never the whole current, since a part shunts off through the muscle itself.

A theory of muscle contraction possessing very ample support in observations both with polarized and with non-polarized light has been advanced and held by Engelmann, to the effect, substantially, that the substances comprising Bowman's discs increase in diameter and diminish in thickness by receiving between their sarcous elements the main watery portion of the sarcoplasma, both of which processes must, as indeed the muscles of insects show, occasion a shortening of the fibre. As the causation of the watery imbition, he postulates a marked local rise of temperature due to chemical processes, such as is in lower degree well known respecting the muscle as a whole on contraction.

Concerning the part which electricity may play in such a causation it is obvious aside from our knowledge of the electric phenomena of muscle, as we would add, that scarcely another force is so adapted to "set off" a mechanism primed to sudden action.

Special Physiology of Nerve.—An amœba needs no nerves since it is unicellular, an insect but few ganglia since it is small and its functions instinctive, or in other words, simple. Even a reptile, although possessing the longest medulla spinalis is not far removed from nervous simplicity, yet it enjoys on the other hand the possession of medullated, *i. e.*, highly isolated nerve fibres.

Whereas in crayfish and lobsters the nerves are enclosed only in connective tissue sheaths, although manifold, all vertebrates but the lowest disclose on all nerves for skeletal muscles a myeline sheath, the chief constituents of which are

fats containing phosphorus, that differs indeed from paraffin in that contain and absorb water but are nevertheless good insulators for weak currents even when broken as on the nerve fibre by the sectional nodes of Ranvier. From experiments with chloroform and other solvents of fat it is however probable that the myeline sheath also plays a part in the conduction of the nervous impulse by reason of its peculiar constitution.

The second fact of prime importance in the electro-physiology of nerve, is that in contradistinction to the ganglion cell the nerve will conduct an excitation whether natural or artificial in either direction equally well.

The specific differences existing in the nervous system, whether sensor, motor, or of special sense, reside chiefly in the nerve endings on the periphery, reinforced by the connections at the centres, in part through the ganglia in part through their dendritic branches. That nerve fibrillæ traverse ganglion cells has been indubitably demonstrated by Spathy and Bethi. That the neurons, each consisting of a ganglion cell with outgoing axis cylinder and ingoing dendritic processes, of which the entire nervous system is quite as indubitably composed, are at least in some cases directly connected with each other, and not as has been hitherto held, always separated by a microscopic interval, is also maintained by these and other observers.

Neuro-electric phenomena have however been systematically observed almost exclusively on nerves alone, chiefly in the amphibian, which antedating man in nature has since then served him to a knowledge of himself, escaping thereby the gastric cavity of one of his own kind.

In all vertebrates the size of medullated nerve fibres differs largely; but in other respects the type is as invariable as it is with muscle manifold. The differences in diameter vary from 2–24 u. in man, but are quite commensurate with those of the axis cylinder itself. The fibres of the third cerebral nerve, which have been especially measured, may increase 6–8 times in thickness from birth to adult age. As degenerate fibres

amongst others of all sizes are found in all nerves, it is probable that new individual fibres increase in size at a more rapid rate.

As in muscular hypertrophy the individual fibres increase both in number and thickness, the same is perhaps true respecting the nerve, at least at the periphery, where nerve fibre branches into some 40 fibrils for muscle enervation.

The average like the largest sensor fibres are smaller than the corresponding motor fibres. The largest fibres are also the thickest. Near the periphery, at a node of Ranvier, each fibre more or less often divides into 2–5 branches of lesser diameter, having together however a greater cross-section than that of the original fibre.

The structure of the axis cylinder is still a subject of controversy, yet there is little doubt that it is normally fibrillar.

The chief structural characteristic of the nerve fibre is the essential difference between the axis cylinder and its sheath, whether myeline or of connective tissue, for in this resides, as has been sufficiently shown, the capability of transmitting a wave of polarization as previously mentioned.

The gray or non-medullated fibres occur in man and the higher animals chiefly in the sympathetic system and in connection with non-striated muscle.

Medullated fibres are composed chemically of albumen, the nerve fats lecithine, cholestearine and protagon and cerebrin, and about 70% of water.

The composition of nervous substance has, however, outside of the questions of isolation and conduction, but slight significance, since the nerve does not perceptibly tire even after continuous application of strong excitants, and consequently is not in all probability subject to consumption of substance from functional activity.

The excitability of nerve is far greater than that of muscle and is subject to variation by a number of agents. It is diminished by carbonic acid and increased at first by alcohol.

It is increased in an isolated nerve upon fresh section, and furthermore by the abstraction of water by simple drying, by glycerine or by concentrated salt solutions. It is diminished by œdema and curare poisoning which induces œdema.

The conductivity of nerve, which is but the natural excitability in its course, in contradistinction to lateral excitability towards extrinsic agents, is diminished by cold and by alcohol.

As previously stated the condition of anelectrotonus diminishes or abolishes the conductivity of a nerve during the time of flow of a polarizing current.

The velocity of the excitatory wave in human nerve reaches about 40 meters per second. Cold reduces and heat raises it.

The intrinsic excitation of nerve by heat or by chemical agents is not susceptible of graduation nor of repeated application. On the other hand, percussion and with increased exactitude the electric current, especially in the form of induction shocks, may be employed in a regulated strength by means of excitation. Induction currents are only inefficient when traversing the nerve direct transversely. In all other cases an excitation is produced that with increasing strengths of currents rapidly reaches a maximum often at double the initial strength.

In a very sensitive nerve as in a batrachian previously kept at 0° C., an induction break current will excite having but 1:5000 of the strength of the maximum shock from a standard Du Bois-Reymond machine supplied with a Daniell cell. The exciting current applied either to the tongue or the moistened eyelid yields no sensation in this case.

Induction currents repeated with sufficient frequency yield as with the muscle a continuous tetanus of greater height than a single muscular contraction. 20 shocks per second or even less suffice at ordinary temperatures for this purpose as above stated.

Since single muscular contractions pass over more quickly with rising temperature, a greater frequency of the induction current is required in the warmth than in the cold.

The period of latent excitation, which elapses between the application of an exciting current to a nerve and the muscular response is greater than with direct muscular excitation and is therefore summed up of at least two components, namely, the

time for the transmission of the excitation along the nerve fibres and fibrils to their endings on the muscle cells, and the latent period of the muscle by *this mode* of muscular excitation. Owing to the exceedingly weak impulses reaching the muscle thereby in comparison those of direct excitation its latent period is longer than the requisite time for nerve transmission plus the latent period of direct electric excitation of muscle.

The electric phenomena of nerve are in all respects similar to those of muscle and only differ in being weaker. The potential of cut nerves and doubtless also of uncut ones is as compared with muscle inordinately various. The differences chiefly reside in the relative number of fibres.

Non-medullated nerves by reason of the absence of the thick myeline sheaths, show, especially in the lower orders of life a high potential not only for their cross-section but also absolutely. The nerve of the lobster's claw stands on a par with the spinal cord of the cat with a potential of 0.05 volt. The sciatic of the dog and cat yield 0.02 V. of the rabbit and the duck 0.025 V. The preponderance in size of the thighs in the latter animals is to be remembered. The non-medullated olfactory of the pike yields more than double the potential of the optic in this animal although but half the size.

The mid-point of an excised piece of nerve is a positive, either cut end a negative pole as in a galvanic battery.

Other points of the natural surface show a lesser potential over the cut since a lesser number of elements come into the circuit. The whole piece of nerve may be considered as two batteries of opposite arrangement joined at one end. On completing all to a circuit no current flows. Each half has the same potential and yields alone the like current. One-quarter and three-quarters give 50% of the maximum current, etc., in the latter case by the mutual nullification of the mid-quarters of the double battery.

The fact that whatever piece of a nerve be excised the point of greatest potential is always at or near the middle shows that the unusually active processes of nerve tissue death at

the cut ends control the direction of potential of all intervening parts and for each half in the same manner.

This phenomena has certainly hitherto received insufficient attention since it is typical of the chief characteristic of nerve as of muscle, namely, their extrordinary electrical lability. It doubtless also stands in close connection with the conduction of excitation which always follows with a wave of changing potential. In the otherwise intact animal such waves have been observed upon local cerebral or even upon adequate peripheral excitation when applying the receiving electrodes of a capillary electrometer one near the other on the cut end of a motor nerve in situ.

A wave of excitation in an excised piece of nerve may be observed under electrical conditions closely imitating the normal by placing non-polarizable electrodes on its surface at each side of the equator, so that no current flows through a delicate galvanometer in the circuit, since the potential of each point led off is equal and positive. Upon then exciting the nerve outside of one of the electrodes, whether electrically or mechanically, so soon as the excitatory wave, which is negative, *i. e.*, a reduction of the positive polarity of the surface, reaches the nearer electrode a current will flow toward it through the galvanometer and continue as long as the wave is engaged in passing, to be followed after an interval by a current in the opposite direction during the time that the wave passes the further electrode. These are the "currents of action" of nerve in response to a wave of "negative variation" of the positive polarity existing on its surface.

It is not probable that normally in the organism such *currents* as these flow within the nerve since no adequate *circuit* is present; but just such a wave of altered polarity may certainly and in all probability does pass along the nerve.

As previously set forth there is no serious obstacle to the view, that such an electric wave makes up the sum and substance of nerve conduction, so soon as the fact is realized, that the simple conduction of electricity through an electrolyte is not only fundamentally different from that through metals, but also proceeds with a velocity incomparably slower.

Electrolysis.*—Electrolysis is the decomposition of certain substances by the passage of an electric current through them, re-arranging their atoms to form new molecules. Of the liquids there are three classes, one which does not conduct electricity, such as turpentine and petroleum, and, consequently, are not acted upon by the current. Second, those which conduct the current without decomposition, such as mercury, and, third, those that conduct the current and are decomposed by it. To this class belong all the compound liquids such as acids, alkalies and the basis, of which the human body is composed.

Water when perfectly pure is practically a non-conductor, but if there is the least impurity in it, it both conducts and is decomposed. The decomposition of water by the passage of an electric current through it, is perhaps the simplest form of

FIG. LXXIII. Needle for Performing Electrotyris.

electrolysis. If the two poles of a galvanic circuit, attached to two platinum electrodes, are immersed in a glass of ordinary water, and a current of sufficient electro-motive force to overcome the resistance be allowed to pass, gas will be evolved at both poles; hydrogen from the positive and oxygen from the negative. This gas is set free in bubbles on the surface of the electrode, to which they apparently adhere for a moment, then break loose and rise to the surface. If an apparatus be so constructed that these gases are collected, it will be found that the volume of hydrogen will be about twice that of oxygen, which corresponds to the chemical composition of water, H_2O.

All substances which are capable of decomposition under the influence of an electric current are called electrolytes. The atoms of an electrolyte which are re-arranged to form new

* The remainder of this section is written by the author.

molecules, and which are collected around the two poles, are known as the *ions* of an electrolyte, and as the negative pole is known as the cathode, those which collect around that pole are known as *cations;* and as the positive pole is known as the anode, those molecules which collect around it are called *anions*.

If electrolysis is produced, of more compound substances than water, we find that the ions are more complex also. In fact, the different chemical formulæ of the cations and anions of some compounds are very long. Suffice it to say, that hydrogen and the alkalies are attracted to the negative pole or cathode and become cations, and oxygen, acids, chlorine and all non-metallic salts are attracted to the positive pole or anode and become anions. A recent hypothesis of electrolysis is based on the theory that all substances, except metal, conduct electricity by connective action, and that molecules dissociated into their atoms are capable of receiving an electric charge and conveying such charge as a medium of transportation. If this be true the atoms become the charged ions, and after giving up their charge at the electrodes remain at that point.

If we introduce the two poles in the form of platinum needles into a piece of fresh beef, the difference in their action is very noticeable. The acids, oxygen and chlorine which collect around the positive pole or anode produce a dry, hard eschar, having a fibrinous appearance, and the needle will be removed with difficulty even though the platinum is non-ozidizable.

Around the negative pole or cathode, the eschar takes a much larger space and instead of its being hard and unyielding is soft and very pliable; in fact, the tissues are liquified. This mass is filled with hydrogen bubbles which escape with a crackling sound. The same distinct action of the poles is manifest if we introduce them into blood. The clot formed around the positive pole or anode is very hard and unyielding and is not easily absorbed, but around the negative, while there is a clot, it is of a soft liquified character easily broken up by pressure and absorbed.

Chemical Galvano-Caustic Action.—If we apply the two electrodes to the surface of a vascular membrane, we also find a difference in the action around the two poles. This is what is known as the chemical galvano-caustic action of a current, but which is simply electrolysis applied to the surface. The eschar which is produced around the negative is soft and liquified filled with hydrogen bubbles, while that produced around the positive is dry and hard. If we examine the cicatrix after electrolysis we find the eschar remaining differs also for the two poles, that around the negative having a tendency to irritability and to be non-contractile, while that around the positive is hard and not easily irritated, and has a decided tendency to contract. These facts should be taken into consideration in removing a nævus or other blemishes from the face, where a bad looking scar would be a deformity. The equalizing effect of the two poles will very much modify the scar.

These two distinct actions of the poles furnish indications for their selection in electrolysis. When the object is the destruction of hard fibrous growths, we must obtain the liquifying action of the negative pole, which is not only greater in its destructive action, but the soft liquid eschar is more easily absorbed than the dry contractile eschar of the positive pole. On the other hand, in those cases where we wish to obstruct circulation, as cutting off the nutrition of a tumor by performing electrolysis at its base, or coagulating the blood in an aneurism the hard unyielding clot of the positive pole is better for the very reason that it is not readily absorbed. In the galvano-caustic action the contractile tendency of the positive eschar makes it remarkably hemostatic in its action, thus calling for its use in those cases of hemorrhagic fibroids where a hemostatic is indicated. The various indications for the poles will be given in the technic of each operation.

Electrical Osmosis.—We have seen that alkalies and hydrogen collect around the negative pole or cathode, and that acids, oxygen and chlorine around the positive pole or anode; it is therefore self-evident that if these ions collect around the poles to any amount, they must be drawn from the electrolyte.

The fact is all the fluid and tissue within the electric field between the electrodes are involved in the electrolytic action. The fluid substance is broken up, and the molecules formed by the new combination of atoms passed from every part of the electrical field through the tissues to the poles. This passage of the ions, *i. e.*,—the alkalies and hydrogen in one direction and the acids and oxygen in the other direction—through the tissues to the poles, is known as electrical osmosis.

The Production of the Eschar.—It is the alkalies and acids and other ions composing the anions and cations, collecting around the poles which produce the destruction of tissue and the coagulation of blood. If the same chemical compounds which collect around the poles could be injected into the tissue and held in the same position, they would undoubtedly produce the same results. The chemical compounds, which collect around the poles, are held in position by affinity for the electrode, and if the tissue is of equal density they will be found to be equal on all side. Of course the greater the amperage the greater the decomposition, and the greater the amount of ions which collect around the poles there will be a corresponding larger eschar produced around the electrodes. If the density of the tissue is not the same on all sides, such for instance, as when the needle is introduced at the base of a hard dry wart, where the tissue underneath is much softer than above, the escharotics will diffuse more rapidly in the soft tissues, it is, therefore, not as safe to estimate the amount of electrolytic action which takes place by what can be seen on the surface, as it is when the tissues are of equal density on all sides.

Absorption After Electrolysis.—After tissue has been destroyed by electrolysis absorption takes place. There are undoubtedly many factors entering into this process. Injury has been produced to the tissue, and in order for nature to repair this injury it must first clear away the debris; this it does by absorbing it and throwing it off through various excretory channels. The absorption varies with the circumstances. The soft liquid eschar of the negative pole is more readily absorbed

than the hard one of the positive. The greatest absorption is in the large cystic tumors, when quantities of fluid are absorbed within a few hours after the operation and thrown off through the kidneys. This has been ascribed to the cataphoric action of the current, but it does not entirely account for it, as it makes no difference which pole is introduced into the sack, the absorption is the same.

Catalysis.—If sponge electrodes, or any other surface electrodes that are absorbents, such as cotton, clay, &c., are employed, and the current is passed through the body or a part of it, the same process of disintegration of tissue takes place, and ions are collected around the pole as when needles are introduced into the tissue. The oxygen, acids and chlorine are attracted to the positive pole, and the alkalies and hydrogen to the negative, but the reason we do not get the same local effects around the electrodes is because they absorb the ions. If metal electrodes are applied to the skin, there will be the same destructive action taking place as if the needles were introduced into the tissues. The disintegration of the tissue by simply passing a current through it without producing local effects, is called catalysis. Electrolysis is both the interpolar with the polar effects, while catalysis is simply the interpolar without the local effects.

It is, however, wrong to suppose that it is impossible to cause local destruction with sponge electrodes, for if a current be given very strong and for a continuous length of time, the sponges become incapable of absorbing all the ions collected to them, with the result of destruction of a certain amount of tissue. Of course the thinner the sponge the nearer the metal conductor comes to the surface of the body, and the more liability there is to get local action.

Metallic Electrolysis.—The ions which are collected around and set free at the two poles, have affinity for certain metals, attacking and disintegrating them, and thereby form new compounds. The ions which collect around the negative pole have but slight affinity for metals; in fact, it is claimed they

do not affect any. We believe, however, it has been demonstrated that aluminum is slightly affected by cations. The anions set free attack many of the metals; copper, zinc, iron and silver are readily attacked and dissolved, while platinum and gold are not appreciably affected, and aluminum but slightly so. It is for this reason that we use platinum or gold, preferably the former, for the positive electrodes when we do not wish to get the electrolytic effect on the electrode. Aluminum, however, is so little acted upon that, with a little care in keeping the electrode polished, it can be used upon the positive pole for all ordinary gynæcological work.

In metallic electrolysis the acids, chlorine and oxygen, which are collected around the positive pole, instead of attacking the tissues and destroying them, attack the metal electrodes forming a new compound which in turn attacks the tissues. There is no doubt that some ions do not have affinity for the metals, and, consequently, exert the same electrolytic action that they would if platinum was used; we, therefore, in medical electrolysis, have a combined destructive action which is always greater than in simple electrolysis, and it is also found that the natural hemostatic properties of the positive pole are greatly increased. In all cases of metalic electrolysis the general characteristics of the eschar of the positive pole, produced by simple electrolysis, are present no matter what metals are used. But this characteristic is somewhat modified according to the metal used. More than twelve years ago we used metallic electrolysis in hydrocele and other cystic tumors, and reported some cases of ovarian cysts treated in this way.

Since that time, through the efforts of Dr. Gautier of Paris metallic electrolysis, so far as it refers to copper, has been brought to the notice of the profession. Gautier has had the residuum of cupric electrolysis analyzed and finds it an oxychloride of copper, the formula being ($CuOCuCl_2$). This proves that the chlorine set free at the positive pole is an important factor in metallic electrolysis. After metallic electrolysis has been produced it is difficult to remove the electrode;

this is owing, partially at least, to the cataphoric action driving it into the surrounding tissue, thus giving its destructive action a much wider range. The electrodes, however, are easily removed if the current is reversed for a few moments, allowing the cations to collect around it and loosen it.

PART TWO.

ELECTRICITY

IN

MEDICINE AND SURGERY

PART TWO.

Electro-Therapeutics.

ELECTRICITY IN MEDICINE AND SURGERY.

SECTION ONE.

General Electro-Therapeutics.

In the past electricity has been looked upon by some physicians as a great therapeutic agent, while others have discarded it as useless; now, however, the medical profession as a whole believes more or less in its therapeutic value.

There are various reasons why electricity has not advanced much faster and held a higher position in therapeutics at an earlier day. At first the apparatus that was used was defective. Then the earlier experimenters, or most of them, thought one form of battery was as good as another, and would use the galvanic, faradic or static, as their fancy dictated, not realizing that each had its special sphere of action. The failure to obtain results which had been expected from the reports of marvelous cures by both untrustworthy and incompetent observers, has had no little share in prejudicing physicians against electricity. Being an agent of wonderful demonstrative power, electricity furnished such a good opportunity for charlatans that it has been one of their chief fields of action, and, consequently, they have done much to throw it into disrepute in the minds of the people. Nearly all these obstacles have now been overcome. The time for quackery to affect the human mind is limited, and, while electrical apparatus is at present far from being perfect, it is about all that can be desired for therapeutic purposes. The indications for the use of the different currents are fairly well established and fast de-

veloping. The utilization of this agent is no longer confined to charlatans and an inferior class of physicians, but the subject is being taken up and thoroughly investigated by original thinkers and scientific men, which is the surest guarantee of its merit and its success. Of course all former observers were not unscientific, for some of them ranked among the highest authorities, but many of them were not of that class.

Electricity is not a cure-all. It has its special sphere of action and indications the same as other remedies, and the more closely these indications are studied and the treatment applied accordingly, the surer will be success.

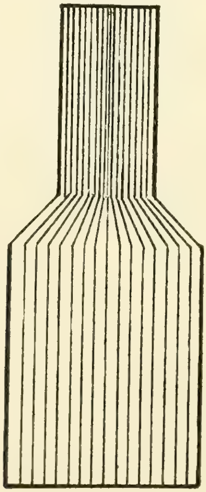


Fig. I.

It also has its successes and its failures. Many physicians will try it once, and if it fails discard it altogether; yet that same physician would try salicylic acid in rheumatism again and again, even if it failed several times, which it would be sure to do. Electricity should not be discarded without a trial at least a second time, because it failed in the first, any more than any other remedy should be discarded under the same circumstances.

The Human Body as a Conductor—Density.—By the term density is meant the relative proportion of the strength of current to the transverse section of the conductor through which it passes; for example, if a certain strength of current—say twenty milliamperes—is passed through a conductor one inch square, and the same twenty milliamperes passed through a conductor two inches square, the density would be four times as great in the former as in the latter, because the current would be diffused through four times as much space in the latter case. Fig. I, which is taken from Erb, illustrates this. One can easily see how much more compact—otherwise how much more dense—the threads representing the electric current are in one part than they are in the other.

The integument, being a poor conductor, forms a large proportion of the resistance to the current in the medicinal use of electricity. This resistance varies with circumstances. If the skin is dry, its resistance is much greater than when well moistened; therefore, when it is desirable to penetrate the skin with the current so as to effect the underlying tissue, an electrode of some material that can be wet must be used. The conductivity of the skin will also be increased if this electrode is placed in a position for a few minutes before the current is allowed to pass, so that the moisture will penetrate it. We have seen a milliampere-meter needle pass from 50 to 120 without adding to the voltage in the treatment of fibroid tumors, when the current was turned on, the moment the abdominal electrode was placed in position. If this electrode is placed in position two or three minutes before the current is allowed to pass, so that the skin becomes well moistened, no such increase will occur. If the electrodes are wet in a solution of warm salt water the integument will absorb the moisture more readily and completely than when fresh water is used, and will, consequently, show less resistance.

In applying electricity to the surface we should take into consideration the parts upon which we wish to concentrate the action of the current. If it is the deep nerves and muscles, the surface resistance should be reduced to a minimum, but if

the sensory nerves are to be acted upon, we should not try to reduce the surface resistance, for the sensory nerves are largely distributed to the skin, and the greater the quantity of electricity expended on the surface, the greater its action upon them. Here we use metallic electrodes next the skin but care should be exercised to prevent. electrolysis taking place if the galvanic current is used, by keeping the electrode constantly in motion. The metallic brush is often used for this purpose.

The interior of the body, while not a good conductor as compared with metals, is a much better conductor than the integument. In order to understand thoroughly the application of electricity, we should have an idea of its distribution through the body. Let us imagine the electric current to be a number of parallel lines, the greater the strength of current the greater the number of lines, and the greater the number of lines in a given space the greater the density. If we place the positive electrode on the abdomen and the negative on the back, as in Fig. III, we have a current passing from the positive to the negative. If this figure is studied one will see at a glance that the greatest density of current is just beneath the electrodes. From this the current spreads; in the interior of the body, the greatest density is in a straight line between the electrodes, because in passing in a straight line, the current has a shorter distance to traverse, and, consequently, has less resistance. Therefore, when it is our object to affect a lesion in the interior of the body, we should so place the electrodes, that the diseased part will be in a direct line between them. If one electrode is larger than the other, as in Fig. IV, the density of the current will be much greater near the smaller; consequently, when we use one as an active electrode and the other simply to connect the current on some indifferent part of the body, as on motor points, the inactive electrode should be as large as can conveniently be used.

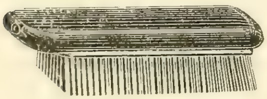


FIG. II. Metalic Brush.

The above serves to illustrate the passage of a current when an electrode is placed on either side of the body; but it

is important for us to understand the distribution of the current where both electrodes are placed on the same side of the body, as in Fig. V. It will here be seen that between the electrodes the greatest density of the current is just underneath the skin. If we compare Fig. V, with Fig. VI, we perceive in the latter that the electrodes are placed further apart; at the same time, the current penetrates the body to a much greater depth, and the greatest density of current is some distance underneath the integument. Therefore, if we wish to penetrate deeply into the tissue with the electric current, such as sending a current lengthwise along the spinal cord, the

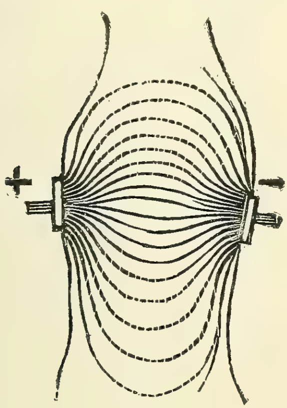


FIG. III.

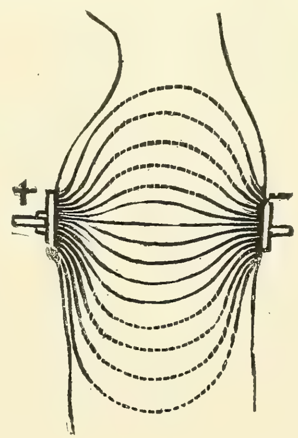


FIG. IV.

electrodes should be placed some distance apart. The above has reference to the galvanic current. The faradic current, although having a greater electro-motive force, does not penetrate so deeply. This is probably accounted for by the short duration of the currents which make up the faradic current and explains why a nerve deeply seated is more easily stimulated with the galvanic than with the faradic current.

Authors have not agreed as to the capability of the current in penetrating bony coverings such as the skull and spinal cord. Some have claimed that the physiological phenomena

produced by the passage of a current through the brain, such as lights before the eyes, dizziness, metallic taste in the mouth, etc., is proof the current does penetrate the skull and produces certain effects on the brain cells. Others maintain that such phenomena are simply reflex and are produced by the action of the current upon the nerve filaments, and cite as proof of their claim that if the fifth nerve is paralyzed all such phenomena are lacking. We believe the contentions of both are more or less correct. It is a question whether the skull or vertebræ do actually conduct electrical currents, such as are generally used in electro-therapeutics, but there are

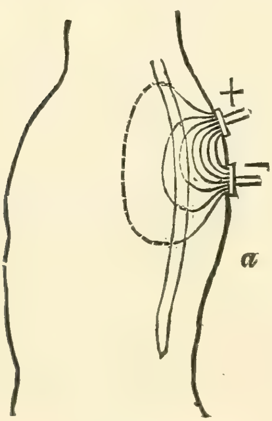


FIG. V.

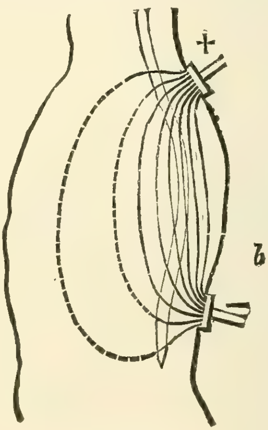


FIG. VI.

many foramina in the base of the skull through which blood vessels filled with blood enter and leave. It is a well known fact that the blood vessels are fair conductors of electric currents. Autopsies on subjects that have been electrocuted prove this. We therefore have fairly good conductors of electrical currents into the substance of the brain. The same is true of the spinal cord; the foramina for the entrance and exit of blood vessels to and from the spinal cord are numerous. Once the current is inside the spinal cord the arachnoid fluid is an excellent conductor leading to the brain. The nerve roots, while not being as good conductors as the blood

vessels, still are fair conductors and should be taken into consideration in this connection.

It is a question whether the nerves conduct electricity to their cerebral or spinal centers when it is applied to the peripheral extremities, or for that matter when it is applied to their trunks. We know, however, that the nerves carry impressions of electric shocks to their cerebral or spinal centers. We believe it is possible to bombard any nerve centre through the medium of the nerve fibers leading from it. For instance, if a static spark is applied to the peripheral distribution of a nerve, the impulse is carried by that nerve to the cell stimulating it and the reflex phenomena is the result. Just what action takes place in this case can only be conjectured. We believe that treatment given over paralyzed muscles due to hemorrhage in the brain assist in the absorption of the clot. But suppose a case where there is a stoppage in the conductivity of the nerve, as in paralysis from chronic neuritis or various diseases of the spinal cord which interfere with the conductivity of the different sets of fibers of which it is composed. It is evident if the stoppage is complete the cerebral or spinal cells are not affected by impulses given below the point of obstruction and are only partially so when the obstruction is incomplete. But here we have another point of bombardment, *i. e.*, the point of obstruction, and the electric shocks may have an effect in overcoming this obstruction and thus opening up a free passage to the center.

We also have a third source from which to effect the circulation in the brain and spinal cord, that is, through the ganglia of the sympathetics. De Watteville objects to the term galvanism of the sympathetic, as it is not known whether we actually galvanize the sympathetic or not, but admits that subaural galvanization does have a certain effect. While the action on the sympathetics is not known specifically, it is but fair to suppose that the ganglia of the neck and of the nerve roots are affected in some way by the passage of a galvanic current through them, and if one were to theorize on it, taking into consideration the known action of the vasomotor nerves

which are a branch of the sympathetic system, we would conclude that the circulation was affected by their stimulation.

General Consideration of Electrodes.—The selection of the proper electrodes is very important. It is impossible to pass a continuous current through the body without producing electrolysis, and whenever electrolysis is produced ions are set free and collect around the electrodes. When we recall that it is the ions which produce the destruction of tissue around the needles in electrolysis, it is evident that if something is not done to protect the integument from their action when the continuous current is used, destruction of the skin will be the result of the treatment whenever any amount of current is passed. This is accomplished by using, between the metal part of the electrode and the skin some material which will absorb the ions or rather allow them to pass through it to the metal surface of the electrode.

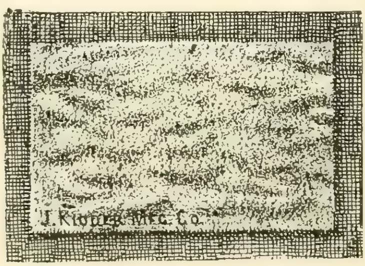


FIG. VII.

It may be gauze, absorbent cotton, sponge, which is most used, felt or clay. Punk backed by a sheet of lead, has also been used for electrodes of large sizes. Nearly all these materials are such poor conductors in themselves that the feeble electro-motive force of the continuous current is not sufficient to overcome them. They must therefore be wet with some solution and this solution becomes the conductor.

As has already been mentioned a saline solution is a much better conductor than water, as pure water is a very bad conductor. However, it is seldom that we find water that does

not contain sufficient impurities to make it a fairly good conductor, good enough for all electro-therapeutic purposes, and it does not destroy the electrodes, while a saline solution soon renders them worthless. We therefore advise the use of plain water.

The remarks just made do not wholly apply to the clay electrode. Clay is a fairly good conductor in itself, as it contains a large per cent. of aluminum. Another advantage possessed by the clay electrode is that it readily absorbs the ions, and there is less danger of producing electrolysis of the skin.

When cotton, sponge, felt, etc., are used, great caution should be exercised to protect any thin spots in them, for if the metal back of the electrode is allowed to come near the skin, electrolysis will surely take place and a deep ulcerated spot will be the result.

Most of the electrodes are made for special applications and they will be considered under the special diseases in which they are used. There are, however, a few that might be termed general electrodes and which may be more properly considered at this point.

Clay Electrodes.—Clay was, as far as we know, first used as an electrode by Du Bois-Raymond, but to Apostoli belongs the credit for bringing it into general use. It may be made in any size or shape required. A piece of cotton muslin of good quality,—for the better the quality the closer the weave,—is cut so that when folded upon itself it is of the required shape and size. To the inside of this, as a lining to it, is stitched a layer of absorbent cotton. The muslin is then stitched together around the edges but an opening is left through which to pack the clay. Artists' modeling clay, which may be purchased at any store dealing in art materials, is best for this purpose. This clay is ground in glycerine, which, on account of its tendency to draw moisture, prevents the clay from completely drying out. The clay is placed in the sack one inch thick and on the surface that is to be uppermost, that is, on the side that is not intended to come next to the body, is

placed a metallic electrode, preferably made of fine wire gauze, which has a connection for the rheaphore soldered to it, and which is so arranged that it is left outside the sack when that is closed.

Some physicians cover the back of this sack with rubber cloth so as to protect the clothing, but according to our experience the water collects around the edges of the rubber and soils the clothing more than without its use. By soaking this pad in hot water for a minute or two the absorbent cotton between the muslin and clay will retain sufficient warmth so that it may be applied to the patient without discomfort. The clay itself requires a long time to heat, and if the absorbent cotton is not used, some time will be wasted in heating it suffi-

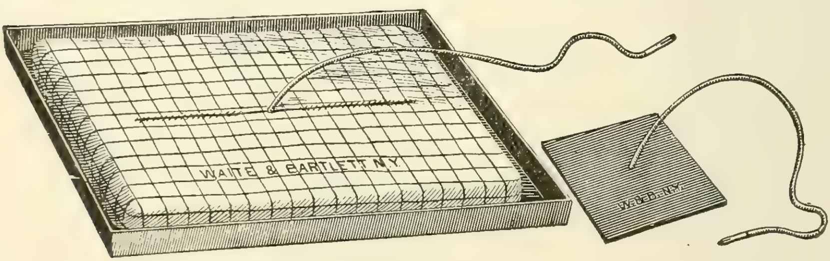


FIG. VIII. Clay Electrode.

ciently before it can be applied with any degree of comfort. There is one very essential point regarding the care of this electrode, and that is, the surface should be kept very smooth, so that it will fit the body perfectly. This may be done with a flat piece of metal or with a roller.

Flexible Hand Electrode.—This electrode is backed with a piece of rubber cloth so as to protect the clothing from dampness of the sponge. The rubber is also of advantage in protecting the operator from the current, as he takes hold of the electrode to move it around in making labile applications. Between the sponge or felt, whichever is used, a copper plate, which has a connection for the rheophore, is placed. This is one of the most useful electrodes in an electro-therapeutist's armamentarium. It may be made large for special purposes or long

for use on the spine. It will carry a current of ten, twenty, or even thirty milliamperes without danger of producing electrolysis of the skin unless, of course, the application be continued for a long time.

General Applications.—In beginning with a case, you will often have to deal with the prejudice and nervous fear of the patient. It is your duty at all times to try and cause but little pain. This is sometimes impossible, but it should be a rule not to hurt or distress your patient in any way until he has become acquainted with the method and acquired confidence in you, when you will have no difficulty in influencing him to bear the necessary burning or other disagreeable sensations. Never allow the patient to get into such a state of mind that he

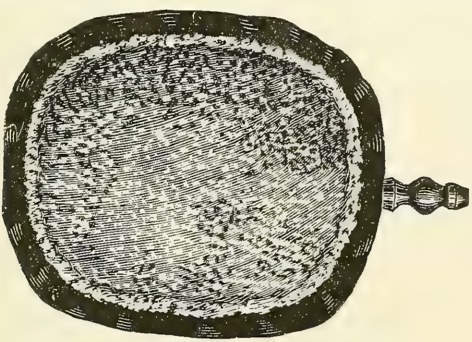


FIG. IX. Flexible Hand Electrode.

dreads the application, for it will certainly hinder, if it does not totally destroy, your chance for success. In order to receive the most benefit from the application of electricity, the patient should lie down thirty minutes or longer after each treatment. It is particularly necessary that a patient should lie down after the general administration of electricity, or he will lose fully half of the benefits that would otherwise be attained. The patient will probably feel a quiet, drowsy sensation, and will sometimes fall asleep if he has a chance.

Labile and Stabile Applications.—When the electrodes are held steadily in one place the application is said to be stabile; when one or both is moved over the body the application is said to

be labile—this produces a vigorous irritation similar to the interruption of a current, but not so marked.

General Consideration of the Application of Electricity.—So far as the choice of currents is concerned, their strength, direction and method of application, information will be given in detail under the special diseases as they are taken up separately in Special Electro-Therapeutics. The action of each current on the muscles and nerves, as well as other parts and organs of the body, have been considered in Electro-Physiology, but as this section is meant largely to supplement that section, or in other words to draw some practical lessons from the physiological action of the currents, it is fitting to make some remarks on the action of the two currents, galvanism and faradism, as a tonic and tissue builder.

Nutritional Action of the Electrical Current.—It has long been recognized that one of the chief actions of the electric current on living tissue is its trophic influence. All forms of electrical manifestation undoubtedly have this action but they vary somewhat under varying conditions. In the year 1893, we undertook a series of experiments to demonstrate the power of galvanism and faradism to develop their trophic influence, and, also, to compare the results obtained from the different currents in health, as well as in certain diseased conditions.*

These tests show, first, that if a very weak galvanic or faradic current is passed through a healthy muscle so as not to produce apparent contraction, they both increased the strength of the muscle very slightly, while there was no apparent difference with the two forms of the current.

Second, that when the currents are increased so that the faradic produces contractions and the galvanic does not, they both show a marked increase in their power to develop muscular strength; but that the faradic leads the galvanic.

Third, that when both are used so as to produce the same force of contraction, *i. e.* (interrupted galvanic current) the increase of strength is about equal with the two currents.

* For a more complete report of these experiments see Transactions of the National Society of Electro-Therapeutists, volume 2, page 25.

Summing up the action of these two currents on healthy muscular tissue, we find that the two currents increase muscular strength; that this increase is in proportion to the strength of current, or at least until a certain limit is reached, and that the increase in the case of both currents is about equal, except that where the faradic produces contraction and the galvanic does not, the faradic leads the galvanic.

Somewhat different are the results in certain diseased conditions. It is found that, in those diseases which interfere with the normal reaction, the galvanic leads the faradic exactly in proportion to the quantitative decrease, and that when reaction of degeneration is present to such a degree as to destroy faradic irritability, that current has no power to improve the strength of the muscles, while the galvanic does have power to increase the strength and improve the trophic condition of muscles, irrespective of its contraction but to a much less degree.

When we come to examine closely into the causes which produce these varying changes, there are some things that throw light upon it, although we must admit that they are mostly speculative. It is evident that the galvanic current has power to increase nutrition and strength irrespective of contractions, while it is also evident that the faradic current has but little, if any, power independent of contraction; after carefully considering the subject we think we are justified in the belief that the galvanic current is capable of producing marked effect on the nutrition of the muscles by its catalytic action alone; and this is true in certain diseased conditions as well as in health.

General Consideration and Application of the Faradic Current.—It is a well established fact that the secondary coil of a faradic battery differs materially in its effects according to the length and size of the wire of which it is constructed.*

The general statement that the current from a coil constructed of long and fine wire relieves pain and that one con-

---

*For the explanation of this we refer the reader to the consideration of the faradic current in Electro-Physics.

structed of short and thick wire produces muscular contraction, should be qualified or it may be misleading. If the coil of long, fine wire is to relieve pain there must first be rapid interruptions of the primary circuit. There must also be a low external or surface resistance, for when applied to the external surface of the body a coil constructed of No. 36 wire is more painful than one constructed of No. 32. The same is true of the short, coarse wire coil No. 22. If this coil is to produce its maximum effects upon muscular fiber the surface resistance must be very low, for when it is applied to the surface of the body it does not produce nearly as vigorous contractions as does a current from a No. 32, the increased voltage of the latter causing it to penetrate more deeply to the muscular tissue.

The soothing effect of the fine wire coil No. 36, and the muscular contractions produced by the thick wire coil No. 22 are only obtained when the resistance is very low,—as in the bipolar treatments in gynæcology. In a painful pelvic cellulitis the bipolar application of the current of tension—from No. 36 wire—will afford relief at once, and in a subinvoluted uterus the bipolar application of the current of quantity—from No. 22 wire—will cause the uterus to vigorously contract. In applications of the faradic current to the external surface where the resistance of the skin is very great, the medium coil or No. 32 wire should be employed if the muscles are to be acted upon. The high voltage of the current from the coil of tension, No. 36 wire, would produce muscular contraction, but its high voltage makes it painful; when a very deeply situated muscle is to be acted upon the current of tension should be used.

General Faradization.—By this method of administering electricity, we bring the entire body under its influence. The patient should have on a loose wrapper so that the physician can get at all points of the body. The feet should be immersed in a tub of warm water, or, if this is inconvenient, they may be placed on a foot electrode. The negative pole of the battery should be connected with the foot-tub or plate. The operator begins by applying the positive pole to the head,

forehead, neck, back, and so on over the body. All points that are sensitive should be studiously avoided, or treated with a current not strong enough to produce a disagreeable sensation. General faradization is tonic in effect, and has a very wide range of usefulness. Although we appreciate its importance we believe it has been over-estimated by its originators (Beard and Rockwell). Its indications will be given in the special diseases in which it is useful, in the department of Special Therapeutics.

Galvano-Faradization.—By this method of electrolization we utilize both galvanic and faradic currents at the same time. The positive pole of the galvanic battery should be attached by means of a wire to the negative pole of a secondary faradic coil, and the rheophores attached to the two remaining poles. The same amperage should be employed as would be used if a faradic current was not in the circuit; to produce this, will, of course, require a much larger voltage, as the resistance of the secondary coil must be overcome. This resistance will vary with the length and size of the wire used in the coil; it will be much greater when the coil of tension, No. 36 wire, is used, and very small when the coil of quantity, No. 22 wire, is in the circuit. The strength of the faradic current should be governed by the amount of stimulation desired, but it should never be strong enough to be uncomfortable.

Galvano-faradization has a strong stimulating action, and should be used in those cases where we wish to get the deep penetrating effect of the galvanic and the stimulating effect of the faradic, such as stimulating the intestines in constipation. The electrode attached to the negative pole of the galvanic current has the greatest stimulating action.

General Consideration in the Application of the Galvanic Current.—The galvanic current has a much wider range of action in electro-therapeutics than any of the other forms of electrical manifestations. The high tension currents are, however, rapidly making inroads into its field and it may in time be forced to take second place to the static or some other form of high tension or high frequency current. Although the electro-

motive force of the continuous current is less than that of the faradic, it certainly appears to have greater action than the faradic on deep structures, such as the brain, spinal cord and viscera.

Electrotonus.—The effect produced upon a nerve by the passage of a galvanic current through it is called electrotonus, and a nerve so affected is said to be in an electrotonic state. That part of the nerve in the neighborhood of the positive pole or anode and affected by it is said to be in an anelectrotonic state; the part affected by the negative pole or cathode is in a catelectrotonic state. There is a neutral point where catelectrotonus meets anelectrotonus, and where the irritability is not changed. If a current of medium strength is used, the neutral point is midway between the two electrodes; if the current is weak, the neutral point is near the anode, but if strong, near the cathode.

One very important point to remember in this connection is that a nerve in an anelectrotonic state has its irritability decreased, and a nerve in a catelectrotonic state has its irritability increased. For this reason we employ the anode to relieve spasms by applying it over the affected nerve, which has its irritability increased, or for the relief of neuralgia by applying it over the hyperæsthetic nerve. For the same reason we use the cathode when we wish to increase the irritability, as in some forms of paralysis. If the current be suddenly broken, anelectrotonus suddenly changes to a state of increased irritability, and catelectrotonus changes to a state of decreased irritability; therefore, in the therapeutic use of electricity, where it is desirable to derive benefit from the continuous effects of anelectrotonus and catelectrotonus, the current should be gradually raised to the maximum, and as gradually decreased.

There has been much controversy among physiologists as to the continuous effect of anelectrotonus and catelectrotonus. On our part, while we do not believe in a system of therapeutics based entirely on the electrotonic theory, we are satisfied that, in certain pathological conditions, when the current

is gradually increased and gradually decreased without any interruption, the effects do continue, the time of continuance varying with the strength and duration of the current used, the individual, and the character of the disease for which it is given; but, as we have intimated, there is danger of carrying the polar action of the current too far.

We do not wish to be understood as saying that the anode is always to be used to relieve pain, for the cathode will often be more effective. It has long been known by practical electro-therapeutists that the cathode is better to relieve chronic muscular rheumatism than is the anode. Still, we have often heard physicians recommend the use of the anode, and have also read the same advice in text books, on the theory that the anode relieves pain. As at present understood, muscular rheumatism is due to a disproportion of the work done by the muscle and the amount of nutrition it receives (that is, the nutrition it receives is too small for the amount of work required of it). We can easily comprehend, therefore, why the cathode, with its power to increase irritability and its greater power to increase nutrition, is more prompt to cure the disease.

On the other hand, Dr. Mundé a few years ago reported a case of sciatica due to pelvic inflammation and effusion, in which he had administered morphia for some time, and, becoming alarmed with the amount used, finally concluded to try galvanism. He placed the cathode, armed with a ball electrode, on the sciatic nerve through the vagina, and the anode on the lower part of the thigh. Very much to his surprise, the pains were immediately aggravated The next day he called Dr. Seguin in consultation. The latter advised placing the anode in the vagina and the cathode on the thigh. This was followed by immediate relief, which continued for some time and five or six treatments completely cured the sciatica. In this case, had Dr. Mundé thought of the increased irritability caused by the cathode, he certainly would not have placed it in so close proximity to the sore, inflamed, hyperæsthetic pelvis; and had he thought of the sedative effect of the

anode, he would not have hesitated which pole to have used in the vagina.

Central Galvanization.—This is a method of administration of the galvanic current so that all the central nervous system, *i. e.*, the brain, sympathetic nerves and the spinal cord, is brought under its influence. The negative electrode should be of good size and held firmly over the solar plexus. After the hair is wet, the positive pole is pressed firmly on the head and labile applications are made from the top of the head to the occiput, from the mastoid process to the sternum, and from the occiput down the entire length of the spinal column. The application should continue about five minutes, and should be given sufficiently strong to produce a metallic taste in the mouth, when it is applied to the head and neck. Vertigo should be avoided, if possible. From three to eight ma. may be used according to the susceptibility of the patient.

General Electrolization.—This is the method of giving electricity so that all of the superficial and some of the deep muscles of the body are made to contract, thus giving exercise to the entire body. Either current may be employed, but we prefer the galvanic, as it is less irritating, and consequently better borne. Seat the patient on a large electrode,—which is so bent that it presses against the lower end of the spine—and to this attach the positive pole. The negative pole is attached to an interrupting handle electrode which is used to stimulate all the superficial nerves and muscles by interrupted applications to the motor points. From five to ten vigorous contractions should be produced from each motor point. This method of administering electricity is a general nutritive tonic. It gives tone to the patient and at the same time develops the muscles in a remarkable manner. We have seen limbs increase half an inch in circumference in a few weeks under this treatment, with a corresponding increase in the strength, vigor, and endurance of the patient.

Direction of Current—Descending and Ascending.—When the positive pole is placed on the spine or on a nerve near where it is given off, and the negative on a peripheral portion,

or when the positive pole is placed on the occiput, and the negative on the lower part of the spine, the current is said to be descending, as it supposedly runs from the positive down to the negative. When the position of the electrodes is reversed, the current is said to be ascending.

The Sinusoidal Current.—There seem to be three characteristics of the sinusoidal current. First, it is painless; second, it has a great stimulating effect on muscular tissue, and third, it has wonderful penetrating power. A current strong enough to produce great muscular contractions is hardly felt by the patient. In fact, with slow rotation with a permanent magnet sinusoidal machine, vigorous contractions are produced without any apparent sensation, except the muscular sense of contraction, and with the more rapid rotation of the machine, tetanic contractions are produced with only the slighest sticking or burning sensation. As the current is purely alternating, running with equal quantity and equal force in each direction, (see electro-physics) there is no polarization of the tissues, and the entire force of the current is spent upon stimulation. There seems to be a peculiar action in that the current diffuses through the muscles more than any other form of electrical manifestation. For instance, if one electrode be placed on the hand and the other back of the shoulder, while there may be a difference in the vigor of contractions, apparently all the muscles of the arm and shoulder contract with the same force. If both electrodes are held in the hands there is an apparent contraction of all the muscles of the upper extremities and the shoulders; even the shoulders rise, showing that the trapezius muscle is made to contract.

This wonderful diffusion of the current to muscles remote from the point of contact is quite characteristic of the sinusoidal current. It retains muscular irritability when reaction of degeneration is present after faradic irritability is lost, but only for a short time. Its penetrating quality is demonstrated by the fact, that, when applied to the head it produces symptoms which are strongly indicative that it penetrates to the brain. When applied over the epigastric region it will pro-

duce an ejection of the food without causing nausea. This is proof that it acts on involuntary muscular fibre as well as voluntary fibre. Its action upon nerves, especially sensory nerves, is not as yet well understood.

When the machine is rotated rapidly, it apparently has more effect on sensory nerves, but is probably inferior in this respect to the higher potential static and the high frequency current. The clinical use of the sinusoidal current is chiefly in those conditions where we wish to stimulate muscles, producing active exercise of them, such as the Weir Mitchell rest cure, and especially where the muscles are deep seated, as in gastrectasia, chronic constipation, relaxed muscles of the abdominal wall—for which Kellogg recommends it very highly—and in uterine misplacements and versions. It is a powerful tissue builder, especially of muscular tissue. The application of the sinusoidal current does not materially differ from that of the faradic; it is used in many cases with more success than that current, and certainly with less discomfort to the patient.

We have lately had constructed a very slow alternating current machine, by which we are able to make the alternations as slowly as desired. This current is of the sinusoidal variety of alternating currents, giving almost a perfect sine curve. It has been found to be very effective in stimulating the liver and intestines in long standing cases of constipation and other diseases of the abdominal viscera.

General Considerations in the Application of Static Electricity.—Static electricity, as useful as it is and with all its rapid growth in popularity, is as yet very largely used empirically. We mean by this that it does not yet rest therapeutically upon any well defined laws. It has achieved its position purely from a clinical standpoint and is certainly widening its field more rapidly than any other form of electrical manifestation. When we assert that its increasing popularity surpasses any other therapeutic measure, we believe we are wholly within the realms of truth. There has been so far scarcely any electro-physiology of static electricity. Theories there have been in profusion as to the different modes of its action, but as none has been

based on sound scientific research, we have concluded not to give a summary of them here, since they would not materially add to our knowledge in the use of static electricity, and might prove confusing or misleading. We may, however, say that there are two general classes into which the action of static electricity may be divided. First, there is its general action; this is as yet not precisely understood, but that it is a general tonic and perhaps nutritive tonic at that, no one who has used the agent can doubt. Second, there is its local action produced by the spark, breeze or any other form of application which makes it necessary to localize the charges to any special part of the body; here we get a much greater action locally and probably a greater stimulating and nutritive effect.

Electrodes for Administering Static Electricity.—It should be borne in mind in considering static electrodes that static electricity has a tendency to run on or off points and that all oval bodies are more or less condensers. Therefore when we wish to administer the static breeze, we use a pointed electrode, or even perhaps several points, which divides the breeze still more and makes it easier to bear. As a ball is a condenser in proportion to its size, it follows that the larger the ball the greater will be the spark passing from it; therefore two sizes are used. Carbon and wood being poorer conductors than brass and also poorer condensers, they modify the spray or spark and in some cases it may be necessary to use them. All the electrodes necessary are furnished by makers with the machine.

Static Application.—The methods of administering static electricity are numerous and require careful consideration. The severity and length of the spark can be modified by the distance the connecting rods of the machine are drawn apart and the rapidity with which the plates are made to revolve. The greater the speed and the farther the connecting rods are drawn apart, the greater the strength of the charge.

There has been much discussion regarding the polar action of static electricity. That there is a decided polar effect there is not the least doubt. This effect is most marked, however, in the administration of the static breeze and may be com-

pared in its effects to the anelectrotonic and catelectrotonic effects of the positive and negative pole of the galvanic current. The breeze from the positive pole, with negative insulation, is soothing and may be used in acute diseases such as acute sciatica, while the breeze from the negative pole is more irritating and stimulating, and would aggravate the pain and soreness of an acute attack, while its power of stimulation in chronic cases is greater.

The therapeutic indications will be found in the chapters on Special Therapeutics. The methods of administering static electricity are: Static insulation, static breeze, indirect spark,

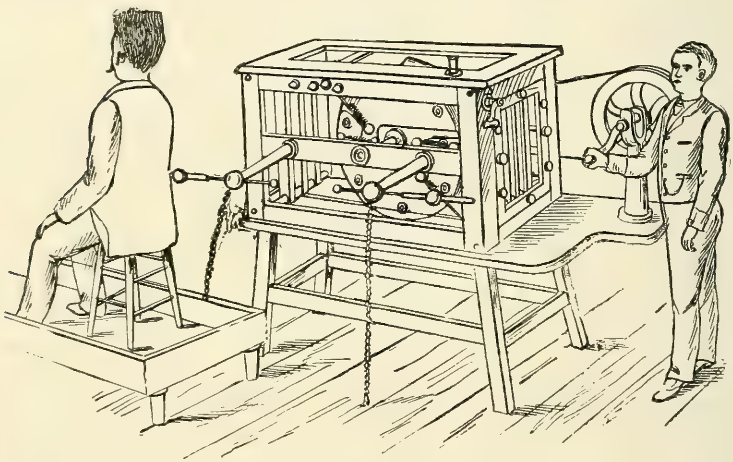


FIG. X.

direct spark, static electro-massage, static induction current, and static wave current.

Static Insulation.—This is accomplished by placing the patient on an insulated platform, as in Fig. X. The stool is connected with one of the poles of the battery, the connecting bars are drawn wide apart, and the opposite pole is connected with the ground, so as to draw off the electricity collecting on it.

Static insulation is a very pleasant way of taking static electricity. The patient is charged with electricity, and it

passes off from various points of the body so gradually that it is hardly noticeable. Care should be taken not to allow any object to come near the patient, or a spark will pass and cause a shock. The hair is deflected and becomes erect, unless oiled. A slight tendency to perspiration is produced, and the patient feels a quiet, soothing sensation.

Indirect Spark.—Fig. XI. The patient is placed no an insulated platform which is connected with one pole of the

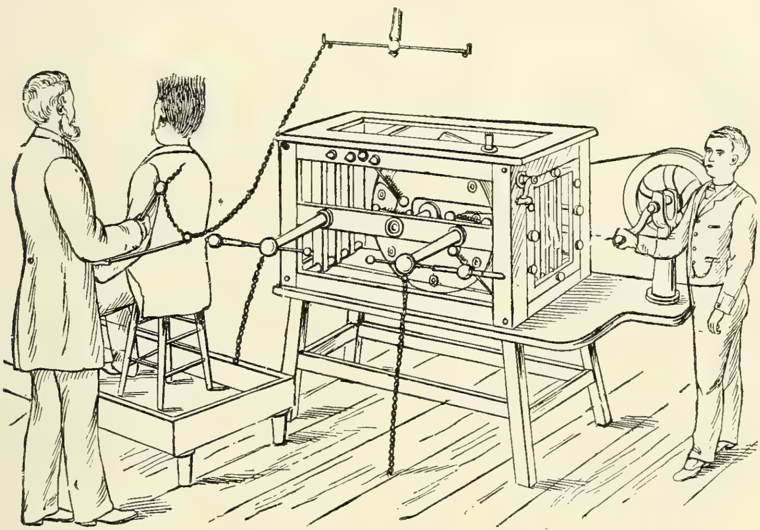


FIG. XI.

battery, while the other pole is grounded the same as for static insulation. Another electrode, connected with the ground, preferably a gas pipe, armed with the large brass ball electrode, is placed a certain distance from the patient (from two to four inches) and a spark passes between them. When a static battery is charged and set in motion, and the connecting rods are drawn a short distance apart, a spark is seen to go from one to the other. This is simply an equalizing of the potentials, one going from the higher to the lower, the other from the lower to the higher, until they meet.

The same phenomena occurs when a patient is on an in-

sulated stool and a spark is drawn from him—the current equalizes its potentials through the body. With the indirect application the earth is also intervened, and the electricity has to take an indirect course through it so that the equalizing of the potentials probably takes place largely at the groundings and but very little through the patient.

Direct Spark.—Fig. XII. The direct spark is the same as the indirect, with the exception that the earth is not intervened between. The patient is placed on an insulated plat-

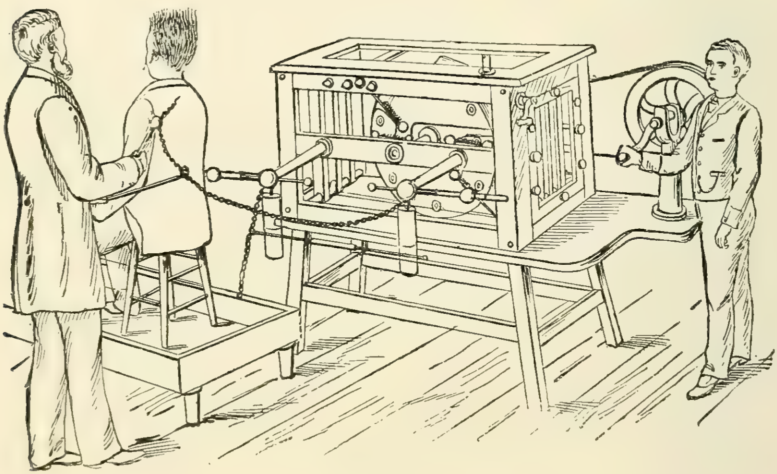


FIG. XII.

form the same as before, but the opposite pole is connected direct with the ball electrode. This is a much stronger application than the indirect spark, and produces greater effects as all or nearly all the equalization takes place in the patient.

Both the direct and indirect spark produce muscular contraction, and both cause irritation of the skin, leaving little round raised spots known as *wheals;* if the treatment has been severe, burning is caused and continues for some time after. If the treatment is on the face or any exposed surface, the part should be rubbed gently with a soft handkerchief to allay the irritation.

Static Breeze.—This method of administering static electricity differs from those just described, in that instead of the electrode being a round ball it is pointed, or it may have many points which divide the electric discharge into a fine spray. The electric breeze may be direct or indirect. The electric head bath, represented in Fig. XIII, is simply the static breeze applied to the head.

With all the above varieties of administering static electricity, Leyden jars may be used or not. If it is desired to get

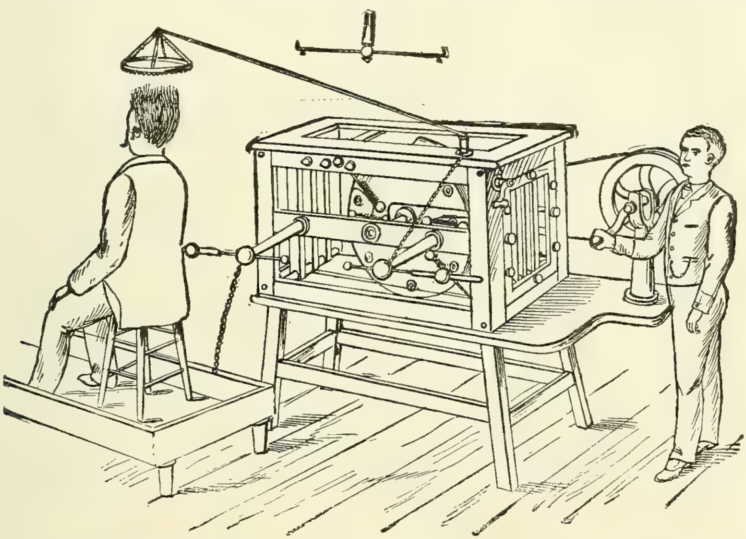


FIG. XIII.

a heavy shock, the jars should be used, the size of the jars to be governed by the severity of the shock desired.

Static Electro-Massage.—This form of administering static electricity does not require the use of the insulated platform. The patient is seated on a chair, with the feet on an ordinary foot plate, which is connected with one pole of the battery, as in Fig. XIV. The roller electrode is attached to the other pole. The connecting rods at the top are placed in contact with each other, and the machine set in motion. The roller is applied to the part that is to be treated, and the connecting

rods very gradually drawn apart, when a pricking sensation will be felt underneath the roller. As it is simply a matter of dividing resistance the current will be stronger the further the connecting rods are drawn apart. Care should be taken not to draw them suddenly apart or you will shock the patient. The best way is to separate them with a kind of twisting motion. This is generally given without the Leyden jars.

The preceding methods of administering static electricity do not require the clothing to be removed, as the electro-motive force is sufficient to carry the electricity through it.

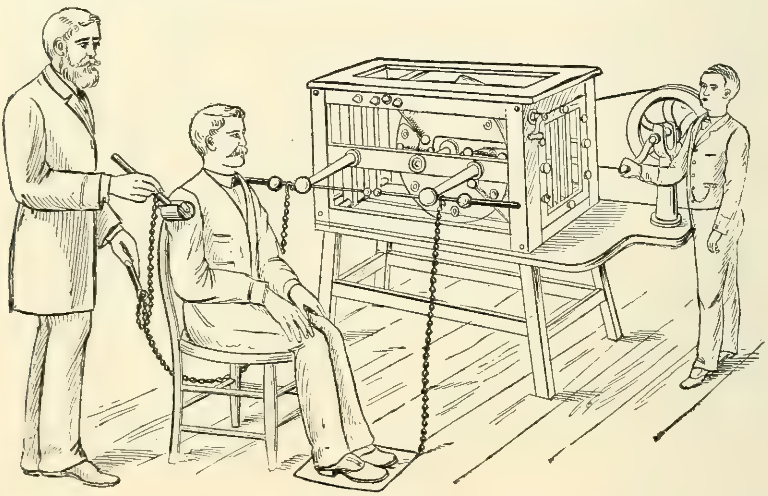


FIG. XIV.

Static Induced Current.—The part to be treated is laid bare the same as for treatment with dynamic currents. A pair of Leyden jars are placed on the machine as in Fig. XV. The rod connecting their outer covering is removed, and two rheophores are attached to the hooks which serve to hold them. The upper connectors are first approximated and then drawn apart the same as in static electro-massage. The strength of current is dependent upon the distance the connectors are withdrawn and the size of the Leyden jars.

Static Wave Current.—The static wave current, so called, which has recently been brought to our notice by Dr. William

James Morton, has fairly leaped into popularity among all believers in static electricity. That it has a certain and specific field of action of its own, no one who has given it an extended trial can doubt, but just what this action is and in just what class of cases it is indicated, is as yet a matter largely of speculation. Only time, with a large clinical use of it, will solve the question.

The method of its administration is simple. The negative pole is grounded and the more thorough the grounding the stronger the treatment. The patient being seated on the in-

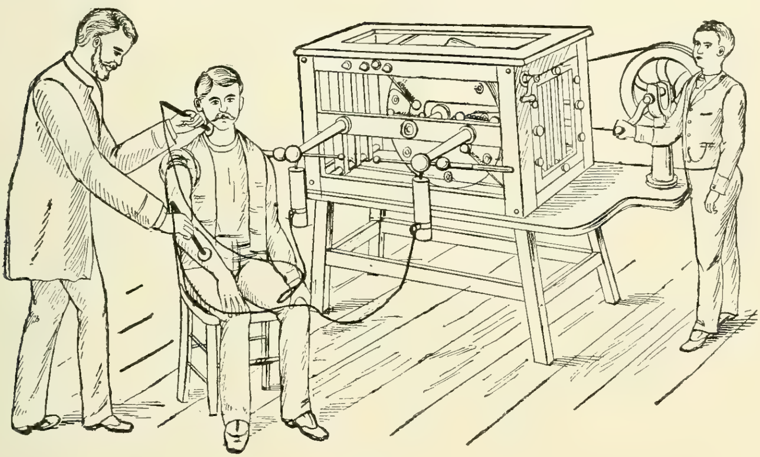


FIG. XV.

sulated platform, an electrode made of tin is placed on the part to be treated and is connected preferably by an insulated rheophore, with the positive pole of the battery. This electrode is generally made long and narrow so that it may be placed along the course of a nerve or along the spinal cord. Other shaped electrodes may be used for special purposes. Tin, being a soft, pliable metal, easily conforms itself to any part of the body. It should be placed as snugly and smoothly to the skin as possible.

The current strength is gauged by the distance the two poles are separated. The manner in which the patient receives the

charge and discharge is simple If it requires fifty thousand volts to produce a spark one inch in length when the poles are separated that distance, and one is thorougly grounded, there must be accumulated on the positive pole an electro-motive force of fifty thousand volts before the spark will pass to the negative pole. With the administration of the static wave current, the patient is simply an extension of the positive pole, and must, therefore, get his share of the fifty thousand volts. If the poles are separated two inches he must get his share, providing the same rule holds good, of one hundred thousand volts. When the spark passes, the entire positive pole, which,

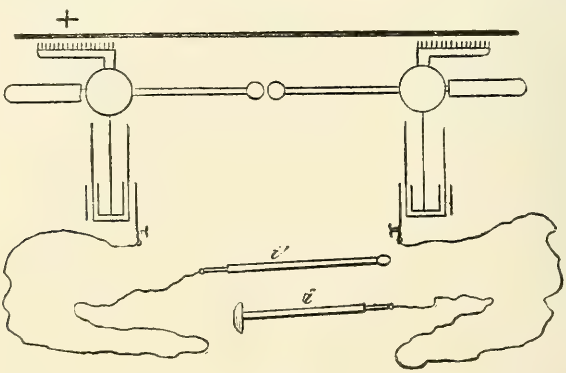


FIG. XVI. How the Static Machine is connected for the Static Induced Current.

in this case, includes the patient, is discharged. As the charges come and go in rapid succession, hundreds a minute, the patient is charged and discharged with equal frequency. This is proved by the vibration of the hair which, when the discharges are not too rapid, is plainly perceptibly, with every charge and discharge. Also if the back of the hand be held two or three inches from the patient the vibrations may be distinctly felt.

As the electro-motive force is so very great the resistance of the body need not be taken into account. And no matter where the electrode is placed over the body, every cell of the body receives its due proportion of the charge, and each must

receive a share of the vibrations. There is no doubt though that these charges and discharges have a decided local effect in the region around the electrodes. This may be proved easily by treating a case of a sprained ankle. If the electrode is placed over the spine very little if indeed any relief is experienced in the ankle, but if the electrode is wound around the ankle relief is prompt and sure.

High Frequency Current.—We approach this subject with much

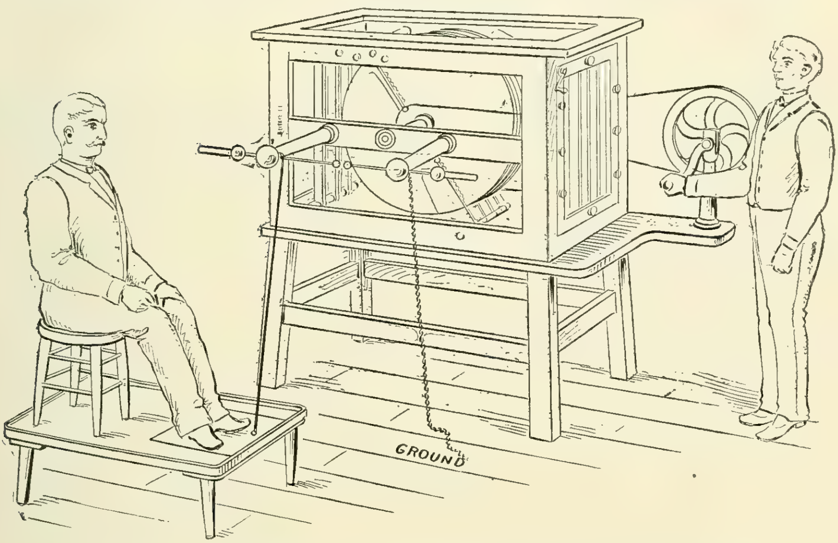


FIG. XVII. Illustration of the Administration of the Static Wave Current to the Bottom of the Feet.

caution. There is nothing in electro-therapeutics concerning which there appears to be more uncertainty regarding its efficiency than the high frequency current. In France great claims are made for it, in Germany it is largely discredited, while England and America may be said to be in the position of observers. That the high frequency current does actively traverse the body is proved by the old and simple experiment of placing the ends of the conducting wires leading from the two poles of the coil into the right hands of two men; when

they grasp the terminals of an electric lamp with their left hands the lamp glows brightly, yet the men feel no shock and scarcely any sensation. Various explanations have been given to account for this phenomena but they need not be repeated here.

There are also certain physiological effects. If a conductor be placed on the back of the hand, although crackling, radiating streams of electrical discharges are both seen and heard, no sensation is felt. If, however, the electrode be allowed to remain there for some time, a deep redness of the skin will be produced and this will remain ten to twenty hours. If the electrode be removed an inch from the hand sparks will pass, producing a decided sensation. It must be admitted though that, both physiologically and therapeutically, the high frequency current is yet in the very preliminary stage of experiment and that its use is largely empirical.

Applications.—There are many methods of administering the high frequency current, but we will confine ourselves to a few that are most commonly employed.

One method is by means of an electrode made of a piece of glass tubing mounted on a hard rubber handle. This glass tube, which is closed at the extreme end, is lined with tin foil like a Leyden jar, and to this is attached by means of a binding post the rheophore leading from the coil. The outer surface of the glass tube is placed against the body and crackling electric discharges are at once produced though no special sensation is perceived. When, however, the electrode is removed a short distance away slight sparks pass which are perceptibly but not disagreeably felt. The same is true when the electrode is placed over the clothing, as here the spark must pass through the fabric.

It is claimed that in this application the patient is, electrically the outer coating of a Leyden jar and that he is charged and discharged by influence charges. It should be remembered though, that a high frequency current is an alternating current, and that the coating on the inside of the glass electrode is charged alternately with positive and negative

charges up to the millions of periods a minute, and the influence charges on the patient must also be alternated with the same frequency. This form of application produces a vigorous effect on the skin and it is claimed that it is very useful in certain skin diseases.

Another form of electrode consists of a vacuum bulb about equal in vacuum to the Geisler tube, the inside of the bulb being connected with the rheophore. The discharges from the coil causes this bulb to light up with a brilliant fluorescence and charges are induced by influence on the outside. If the

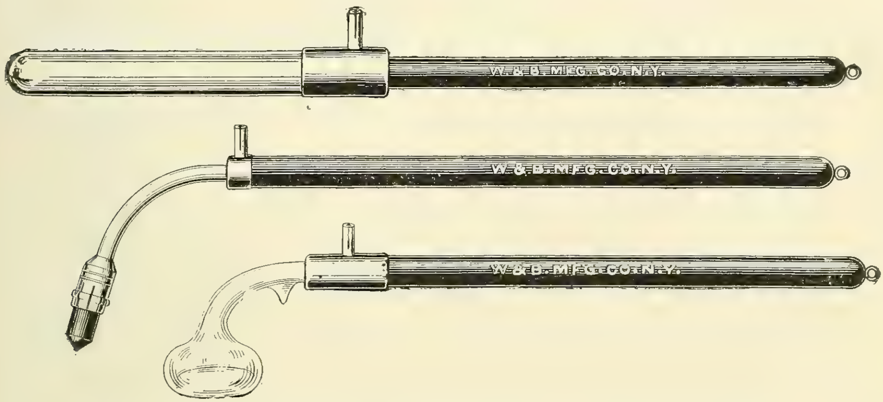


FIG. XVIII. Electrodes for Administering the High Frequency Current.

bulb is placed in contact with the skin, there will be a brilliant display of electric discharges, but no sensation is felt. When it is withdrawn a little, sparks pass the same as with the glass lined electrode. Treatment given with this electrode is milder than that given with the glass-lined electrode, and it should be used over very sensitive spots. This is known as the glass vacuum electrode. The treatment will be strongest when the patient is connected direct to the other or inactive pole of the coil, more moderate when the inactive pole is simply grounded by connecting it with the floor, and least of all when it is not connected with anything. The most even and comfortable treatments are given when the inactive pole is grounded.

When, however, very sensitive parts are to be treated it is best not to ground the inactive pole.

The preceding methods of administering the high frequency current are for local effects. When general treatments are desired, one pole of the coil is attached to the patient while the other is attached to a large metal plate and held a short distance away. By this arrangement the body of the patient and the metal plate form the two coatings of a condenser, the intervening space being the insulator. In France a couch has been constructed which has a large metal plate underneath; on this plate lies some insulating material and on the top of this the patient rests. Thus the entire body is brought under the influence of the charge. A metal cage has also been made so as to let down over and around the patient.

The Electric Bath.—So much has the electric bath been associated with quackery, that it may seem strange to many to see it even mentioned in a work of this character. However, much has been done of late in Germany, England and France to develop the scientific side of the electric bath and with so much success that a book on electro-therapeutics would be incomplete without a mention of the methods employed and what is claimed for it in certain conditions. There are two forms of administering the electric current through a bath; one known as monopolar, the other as bipolar.

The monopolar method simply uses the water as one pole, with the other applied on some part of the body outside the bath. This is easily accomplished by placing one electrode in the tub which converts all the water in contact with the body into an electrode giving the current a very wide diffusion. The other electrode applied to the neck, back, arm or hand concentrates the current at that point, the amount of concentration depending upon the size of the electrode.

The bipolar method consists in dividing the electrodes in the water. For instance one may be placed at either end of the tub or on the sides. With the monopolar method all the current passing must necessary go through the body of the patient, but with the bipolar only a fraction of it goes through

the patient. Hedley has estimated that from five to twenty-five per cent. of the current passing goes through the body while Meylan has placed it at about one-eighth. As wide as this range may seem it is too narrow, for the result will depend entirely upon the relationship of the resistance of the water to the body of the patient. If the resistance of the body and the resistance of the water are equal, and a current be passed through them, one-half would go through each. The variation of the resistance of either would vary the amount of current each receives. Therefore in those cases where it is desired that the body shall receive as much current as possible, neither salt nor any other material which will increase its conductivity should be added to the water. The description of the tub and the dimensions and distribution of the electrodes are best given in the words of Dr. Hedley (Hydro-Electric Methods) who has had a large experience with electric baths.

Dr. Hedley says: "The bath is an ovoid oak tub, 148 c.m. long and 75 c.m. at greatest width, which is about 5 c.m. nearer the head than the foot. Height at head, 68 c.m.; height at foot, 51 c.m. In one form of bath there are five electrodes, fixed to the sides of the bath, the latter being pierced for the passage of the conducting wires. These electrodes are of bright metal covered only by light removable open wooden framework, size as follows:

"Cervical"	28x29 c.m.
"Lumbar"	24x17 c.m.
"Lateral" (2)	26. 5x18 c.m.
"Gluteal" (circular) . . .	30 c.m. (diameter.)
"Terminal" (foot) . . .	22x38 c.m.

"In addition to these there is an electrode for monopolar purposes, consisting of a removable metal rod, one inch in diameter, covered with wash leather. This is fixed across the widest part of the bath, and can be conveniently grasped by the hands. The electrodes are connected, by carefully insulated wires, with seven terminals, and the latter in turn lead to a switch-board, so arranged that by the insertion of plugs any current or combination of currents can be brought into

action, either as anode or cathode. The connection with the battery, coil, or other source of supply, is by means of well-insulated connections leading to two ordinary 'binding posts' on the 'commutator.'"

The temperature of the bath, duration of treatment, and direction and selection of the current should all be governed by the general principle of the action of currents and the nature of the disease for which it is given, the same as in other applications.

There is no special action attributable to the current when given in a bath than given otherwise, except that obtained by the smoothness of the passage of the current and the ease with which large doses are borne; perhaps, however, in its general application its stimulating effects are greater. Jones states that it surpasses general faradization in this respect. Vergnes believed thoroughly in its use for localized effects. He painted with iodine the part on which he specially wished to localize the current in order to reduce the resistance of the skin, and thereby insure the passage of a large quantity of current at that point. This procedure may be effective to a degree, but it is certainly more accurate and scientific to localize the application by means of electrodes.

In France the sinusoidal bath is one of the most popular forms of electrical administration and is recommended in a wide range of diseases.

SECTION TWO.

Diseases of the Nervous System.

DISEASES OF THE BRAIN.—Electricity has long been used for diseases of the nervous system. While the scope of its usefulness is somewhat limited, the indications for its use are well defined and its action is, to a degree, understood. Many claim that its good effects are due largely to suggestion. This we do not believe, but consider that it is due more to the nutritive and stimulating effects of the current. We fail to see though that it makes any difference to what its action is due from a therapeutical standpoint, providing the results are good.

Psychoses.—It cannot be said that electro-therapeutics has as yet gained a definite place in the treatment of mental diseases. There have been some excellent results from electrical treatment, as the number of cases that have been cured is evidence, but there is a lack of uniformity of practice, and the methods of application have been empirical. When we consider that mental derangements are due to a degeneration of the histological elements of the brain and also to a disorder of the circulation of the cerebrum, and when we also consider the great effect that electricity has upon these histological cells and its power to rearrange the circulation, it would appear that we have an agent par excellence for these conditions. But so little is at present known of these histological changes, or even the changes in circulation, and our knowledge of the action of the current upon these centers are so ill-defined, it is not surprising that so little has been accomplished.

The electro-physiological experiments upon the brains of lower animals, with their coverings removed, cannot be taken as a guide for the clinical use of electricity, for the conductivity of the current in its clinical application is probably along the blood-vessels, and is, consequently, not so abundantly distributed to the cortical portions as in physiological experiments. The fault, then, is not due to the agent, but to a lack of an understanding regarding its application.

In studying the reports of numerous cases which have been treated by electricty, we find that the particular class of conditions which are relieved most uniformly and promptly are melancholia and hypochondriasis. These two conditions, which gradually melt into one another, are very often symptoms of neurasthenia. It is, therefore, probable that the results here have been largely due to the tonic effects of the current upon the nervous system. According to Sperling melancholia accompanied with stupor are specially amenable to electric treatment. Other cases of well-marked delusions and hallucinations have also been cured. Those cases in which electricity is contraindicated are acute mania, wild delirium, mania with general nervous hyperesthesia, and especially psychical hyperesthesia.

There is a peculiar feature regarding the cases that have been cured by electricity, and that is, where diagnostic symptoms are similar, the form of treatment that relieves one aggravates another. According to a general consensus of opinion, however, the treatment should consist of weak galvanic currents given for a long time, say for twenty or thirty minutes, and the positive pole applied to the head, as a rule, gives better results than the negative, though in some cases the best results are attained by applying both poles to the head at the same time. The prognosis will be more favorable in those conditions not fully developed, or in conditions of morbid fear with sleeplessneess, than in any well-developed mental derangement. Treatment should be given longitudinally through the head, cathode at nape of neck; with the

anode begin at the forehead, carrying it backward along the sagital suture.

Other methods of treatment, such as central galvanization, have proved more effective in some cases. One form of treatment, which has been highly extolled, is to apply the cathode between the shoulders, and with the anode go thoroughly over the head and the sympathetics of the neck. The treatment should always be given with very weak currents and gradually increased in strength. The patient must be carefully watched during the treatment, and if one form seems to irritate, another should be tried. Good results in hypochondriasis have been attained by giving a light current through the head; this, however, should be done with great care. These treatments may be given in conjunction with franklinization. The static spray alone seems to be the favorite method with some. We have, in a case of melancholia with delusions, effected a cure, the general health being otherwise good, with the static spray. A method recommended by many is to vigorously faradize the skin with a wire brush and thus reflexly stimulate the central nervous system. The electric bath with sinusoidal currents has also been successfully used. It soothes the nervous tension, improves the circulation and by building up the general health assists in mental regeneration.

In periodical attacks of melancholia the treatment should be given during the intervals of the attack. Here the best results have been attained by the continuous application of a very weak galvanic current to the head, both longitudinally and transversely.

Case of Melancholia with Delusions Brought on by Domestic Troubles.—Patient, female, age 36, no children, general health much reduced. The case was of four month's standing,—three months of which had been spent in a sanitarium—when the treatment was begun. The treatment was given at the earnest request of the husband, a physician, but not with any great expectation of benefit. The static breeze (positive) was given for fifteen minutes daily. No other form of treatment was employed. There was a distinct decrease in delusions by

the end of the first week. Delusions had disappeared at the end of second week with general improvement in all symptoms. The patient was discharged at the end of the fifth week cured.

Case of Puerperal Mania.—Patient, age, 28 years. The onset of the disease was the sixth day following the birth of the first child. The second week of the disease the patient was raving. She would run and jump and tear about the room until she was obliged to desist from sheer exhaustion. This was followed at the end of the third week by physical and mental depression. She became taciturn. Mania alternated with depression. Central galvanization was tried at the end of the fourth week with apparent aggravation of the mania and was discontinued. At the beginning of the sixth week, general faradization was given for fifteen minutes daily. Its effect in quieting the patient was marked. It would invariably be followed by from one to three hours sleep. Improvement was steady and treatment was discontinued at the end of the ninth week. One peculiar symptom of this case was that, the patient was unable to pass urine except when water was running from a faucet in her hearing.

Cerebral Hyperæmia and Anæmia.—It has for a long time been the generally accepted belief that if the anode was applied to the occiput and the cathode to the forehead, it would cause an increase in the blood-supply of the head, and that the reverse would decrease the blood-supply. This theory, which has been based mostly upon clinical experience, is to a degree correct, but this treatment is not the best method for cerebral hyperæmia. The fact that the cathode is applied to the back of the neck and the anode to the forehead does not prove that it is the direction of the current that relieves the hyperæmia.

It is, we believe, the location of the cathode upon the back of the neck which decreases the blood-supply. Much better results will, therefore, be attained by placing the anode at some other point, preferably at the lower end of the spine or over the solar plexus, and giving a current of fifteen milliamperes for ten or twelve minutes, a current that cannot be borne

with the anode on the forehead. Symptoms of cerebral hyperæmia will disappear very promptly under this treatment. Whether it is due to the action upon the pons or medulla, or upon the sympathetic nerves at that point, we do not pretend to say, but clinical experience has proved this to be the best method of treating cerebral hyperæmia. Older electro-therapeutists recommended using the faradic brush upon other parts of the body in order to draw the blood into the integument. Much better results will be attained by using the interrupted galvanic current over the motor-points and causing vigorous contractions. This produces an active exercise of the muscles, drawing to them a large amount of blood, more than can possibly be forced into the skin, and in this way relieving the cerebral hyperæmia.

Cerebral anæmia is also successfully treated. Here we find the greatest benefit from the application of the anode to the head. It is pretty generally conceded from a clinical point, that the anode has a more vigorous action in stimulating the circulation of the brain than the cathode. A good form of treatment for cerebral anæmia is central galvanization. Perhaps the most effective method is a combination of a longitudinal current through the head—the anode of the occiput and the cathode on the forehead—about two minutes, followed by central galvanization. General treatments, such as the static spray or sparks or general faradization, may be given to stimulate the general circulation.

Case of Cerebral Congestion.—Male, age, 56 years, a retired colonel of the United States army. When he first came under observation he had been suffering for some years, perhaps ten. His face was always very much flushed especially toward night. He complained of a pressing fullness in the head with great heat. This would increase in the afternoon to a throbbing pain. The afternoon aggravation would be greatly increased by the least excitement or irritation. If congestion became great he would be excitable and irritable which made the condition still worse. He suffered greatly from insomnia, but when he succeeded in getting a good night's sleep he

would feel very much better the next day. The heart's action was irritated and would increase in action from the slightest cause, either mental or physical. He was treated every other day with galvanism, the negative pole attached to a flexible hand electrode about four inches square being placed under the occiput and the positive at the lower end of the spine. Twenty milliamperes were used for eight minutes, when the positive electrode was removed to the abdomen or chest, and the negative electrode was placed over the cervical spine and the same strength and duration of current given. The relief afforded was very prompt, and at the end of two months he was far more comfortable than he had been for years.

Case of Cerebral Congestion.—Male, age, 35, a New York City builder, who suffered great financial losses, was taken with severe pains in the head and other symptoms which indicated a very severe attack of active cerebral congestion and perhaps a slight inflammation. We saw him some weeks after when he was suffering from all the symptoms which go to make up a chronic cerebral congestion, fullness and throbbing in the head, almost turgestened appearance of the face, insomnia to a very marked degree, excitable and irritable, but unable to do mental labor. He became very bald in a few months. The slightest physical exertion would increase the cerebral congestion. The longitudinal treatment through the head, negative on occiput, positive on forehead, was tried at first but with very little benefit. The treatment given in the previous case was then resorted to with very prompt relief. This was given two or three times a week for three months when the symptoms of cerebral congestion had disappeared and the general health was much improved, but not entirely restored to its its former vigor. The patient then drifted away and has not since been seen.

Cerebral Hemorrhage—Apoplexy.—In treating cerebral apoplexy with electricity one is often surprised at the brilliant results attained in one case and the utter failure in another. Conditions that govern the prognosis in general should always be taken into consideration in giving the probable effect of elec-

tricity. If electricity is to benefit a recent case of cerebral hemorrhage, improvement will be manifest within three weeks.

It is a disputed question just when the treatment should begin. Some authors claim that if given very early in the disease it has a tendency to prevent the descending changes which so often follow cerebral hemorrhage, while others declare that its early use endangers the patient to another attack. One thing is certain, however, it should not be undertaken until all fear of cerebral fever has passed. Generally speaking, it may be begun with safety in three or four weeks after the attack.

The principle of treatment is first to try to absorb any deposit which may remain from the hemorrhage and to stimulate the cortical cells, if a cortical lesion, or to overcome the resistance if in the white substance; second, to improve the nutrition of the paralyzed muscles, and at the same time by acting on the peripheral nerves, bombard reflexly the nerve-centers, and thereby stimulate them into action.

The treatment necessarily consists of two parts. First, a galvanic current is given through the head, so that the lesion comes directly within the electric field. Most authors agree that the anode should be placed nearest over the point of lesion, and the cathode on the opposite side. The current should also be allowed to run in various directions through the head, thus increasing its catalytic effect, but the anode should always predominate on the side of the lesion. Whether the electrodes should be applied so as to increase or decrease the supply of blood to the head, is a question which must be taken into consideration by the condition of the patient. Following this, central galvanization may be given for two or three minutes to stimulate all the sympathetic nerves. After this, the anode should be applied to the back, while the cathode, with interruptions, is applied to all the motor-points of the paralyzed part. The faradic current may be utilized for this purpose, as muscular reaction is not lost. This should be carefully done, and never carried to the point of fatiguing

the muscles, as manifested by their diminished vigor of contraction.

By this means we increase nutrition, the muscles regain their normal strength, and also stimulate the nerve-centers through the peripheral nerves. Those cases of late rigidity where there is a sclerosis of the cord, may sometimes receive much benefit from a treatment of the muscles in this way, as it improves their nutrition, tone and strength; but a cure is not to be expected. Frequently paralytic limbs are the seat of pains; the galvanic current applied to them directly in a labile form will generally produce relief. When anæsthesia is present, it should receive the appropriate treatment with the faradic brush. Aphasia should be treated by local galvanization, one electrode, the anode, over the third frontal convolution, the center of Broca, and the other on the larynx of the right side. A current may be given for two or three minutes in this direction, when the motor-points of the larynx should be gone over carefully with the interrupted current, after the anode has been removed to the back of the neck, the same as with the other paralyzed muscles. These motor-points are two in number. The external laryngeal, a branch of the superior laryngeal, supplies the crico-thyroid muscles, its motor-point being just at its division, and is easily reached by placing the electrode along the posterior border of the thyroid cartilage, about an eighth of an inch above a line drawn directly backward from the *pomum Adami*. The inferior laryngeal nerve, which supplies the arytenoids and crico-arytenoidei lateralis, passes under the lower border of the inferior constrictor muscle, just in front of the carotid, and into the larynx, at the point of articulation of the interior cornu of the thyroid cartilage with the cricoid. The motor-point of this nerve is just as it dips under the inferior constrictor muscles, and is found by first locating the point by carrying the finger back along the side of the cricoid cartilage until it reaches the point of articulation with the inferior cornu of the thyroid cartilage. Just back of this point the distinct beats of the carotid artery will be felt. The electrode should be firmly pressed between

these two points, and the nerve will respond. The small-sized Erb electrode should be used.

In addition to all these treatments, which are given to stimulate parts directly concerned in the paralysis, general treatment should be given. Formerly general faradization was recommended by all, but the static breeze has very generally taken the place of general faradization, on account of the ease with which it is given, and it can be utilized here with equal advantage.

Cerebral Embolism.—Many cases have been reported of cerebral embolism that have been benefitted by electrical treatment. However, the success attained depends upon the condition present. Collateral circulation tends to re-establish itself within a very few hours, or days at most, after the attack, and, if it does not, cerebral softening is liable to be the result, when electricity will be of no avail. Electricity will be most potent by beginning about forty-eight hours after the attack, so as to assist in the formation of the collateral circulation. The methods of application given for cerebral anæmia will best answer this purpose. In other respects the treatment recommended for the paralyzed muscles should be the same as in cerebral hemorrhage. If, however, the treatment does not improve the condition within one week, it is useless to continue longer.

Localized Paralysis from Cerebral Hemorrhage.—Any part of the body may be severely paralyzed from cerebral disease. When the paralysis is due to hemorrhage within the cortex of the brain, it should be treated the same as apoplexy of a more general character. The success attending the treatment of these localized forms of paralysis will depend, of course, upon the nature of the central disease. When of a degenerative character electricity will be of little avail.

Facial paralysis of cerebral origin is diagnosed from that of peripheral by the fact that no reaction of degeneration exists. The method of treatment is first to pass a current through the brain so that the lesion is within the electric field, and then to

go over the motor-points of the facial nerve and produce vigorous contractions.

A very common form of local paralysis is that of the muscles controlling the eyeball. Here it is impossible to reach the motor-point, but with a very small electrode covered with absorbent cotton, pressed well into the orbital cavity near the paralyzed muscles, the continuous current will stimulate the nerve, but, of course, not so much as when contractions are produced. In all these cases of cerebral disease the principle of treatment is the same; first, to stimulate the brain centers, and, second, to stimulate the paralyzed muscles.

Case of Hemiplegia.—Male, age, 55, had suffered from attack in March and had partially recovered when a slight relapse, so far as symptoms were concerned, occurred in April; whether there was a recurrence of the hemorrhage or not was not decided. The recovery from the relapse was slow. Electrical treatment, galvanic, transverse and longitudinally through the head and the interrupted current over motor points causing contraction of muscles, was begun the middle of June. Marked improvement followed the first three applications which were given every other day. Treatment was continued six weeks in all when the patient was apparently as strong as before the attack.

Case of Hemiplegia With Marked Descending Changes—Male, age, 59. The attack had been most severe and very marked descending changes had taken place when the patient first came under observation, some six months after the attack. He was still unable to walk, the nervous system was so weakened that he would burst out crying every five minutes, and the pains were very severe. Treatment was given as in the previous case with the result that the headache, from which he suffered greatly, was relieved and in six weeks he was able to walk alone, although very unsteadily. The pains through the limbs and the muscular spasm which had existed from the fourth month showed no signs of improvement. The treatment was then changed to a vigorous galvano-faradization of the entire paralyzed side, using the negative pole of the gal-

vanic; the current of tension of the faradic was employed. A descending galvanic current of some fifteen milliamperes was passed down the spine for five minutes; marked relief followed these applications. Some of it proved to be permanent but not all. One interesting feature of the treatment of this case was that the static, even in the mildest form of positive breeze, seemed to aggravate it.

Case of Monoplegia from Cerebral Hemorrhage.—Female, age, 49. The entire left arm was involved. It appeared suddenly when she was tying her husband's necktie after arising in the morning. The case seemed to improve under medical treatment for four weeks when improvement ceased, and although no other treatment was given for the following eight weeks there did not appear to be any descending changes noticeable. At the end of the third month electrical treatment was first given with immediate relief. In five weeks the arm was restored to its normal vigor.

Case of Paralysis of Seventh Nerve of Central Origin.—The attack followed measles with convulsions when the child was six years of age. It was three years later when we first saw her. There was a slight limited motion, no R. D. and no atrophy. Galvano-faradization, negative pole on face and medium coil, No. 32 wire, was used as strong as could be borne, three times a week. At the same time the little patient was taught to practice several times a day to will the muscles to contract. First she would try and wink the eye, then draw the corner of the mouth, wrinkle the forehead, etc. Improvement was marked and progressive, but it never became so complete that the deformity of countenance was entirely removed.

Cerebral Softening and Sclerosis.—Some cases of cerebral softening and sclerosis have been reported cured by the local application of the galvanic current to the head. This, however, is very doubtful, for there has been no well-known authority, so far as we are aware, that has had anything but failure in these diseases. The cases reported cured, have mostly received both longitudinal and transverse applications through the head, but

the principal characteristics of the treatment were a strong current passed parallel to the sagittal suture.

Chronic Progressive Bulbar Paralysis—Labio-Glosso-Laryngeal Paralysis.—Most authors recommend electricity for bulbar paralysis. Its success, however, depends upon the stage of the disease when the treatment is begun, but even in the later stage it is often capable of ameliorating the condition. In the very early stages of bulbar paralysis no change in the reaction is noted, but as the disease progresses, there comes a quantitative decrease of irritability to both galvanic and faradic current, and the peculiarity of this decrease of irritability is that it increases with the number of contractions, for it will require a greater amperage to produce the same vigorous contractions after a minute or two's treatment than it did at the beginning. This does not have the appearance of being due to a tiring of the muscles so much as it does to an increased rigidity. As the disease progressss still further, reaction of degeneration takes place, the nerve loses its contractile power to both the galvanic and the faradic current and modal changes are noted; but it seldom progresses to the point that anodal opening contractions are stronger than cathodal-closure contractions. In fact, it is seldom that reaction of degeneration is complete even in the very last stages of the disease. Reaction of degeneration probably takes place at the time the degeneration extends from the cells of the medulla to the roots of the nerves, and in order to accomplish a cure it is necessary to begin treatment before this stage is reached. While many cases of bulbar paralysis have been reported cured, it is a question to just what variety of bulbar disease these belonged. Benedict has reported a number of cases, and Erb has also spoken of the brilliant results of electricity in certain forms of bulbar paralysis.

The method of treatment is first to stimulate, by the catalytic action of a galvanic current, the cells of the medulla. Erb recommends the passing of a transverse current through the mastoid process, and then a longitudinal current, but, owing to the severe vertigo that is produced by even slight

transverse currents, dependence will have to be placed upon the longitudinal currents, as much stronger ones can be borne when given in this direction. These should be given as strong as the patient can easily bear, and continue for ten minutes. If bad results occur, a much weaker current must be given, but in order to penetrate these deep cells strong currents should be administered.

The second object of treatment is to improve the nutrition of the muscles. All agree that this can be done; even those who deny the power of electricity to improve the condition of the central cells, admit that it is very useful in keeping up the nutrition of the muscles. This is best accomplished by placing a flexible hand-electrode on the back of the neck, and going over the motor-points with the interrupter-electrode, causing contraction of each muscle five or ten times. If in the later stage the muscles tire under this treatment, labile treatment may be given instead. The motor-points of the face, tongue and larynx, and, in fact, all muscles affected inside the mouth or out, should be stimulated with the galvanic current. Two small hand-electrodes should then be placed on either side of the larynx and interruptions made so as to produce contractions of the pharynx. This is very important, as by this means swallowing may be continued for some time.

Galvanization of the sympathetics should also be given. In many cases there is a painful stiffness of the muscles of the neck, which may be relieved by vigorous applications of the galvanic current. Some recommend general faradization or the static spray to keep up the general nutrition. If success is to be attained treatment must be given often, at least five times a week; daily treatments are even better.

In pseudo-bulbar paralysis, when of cerebral orgin, no reaction of degeneration is present, as this form of paralysis is due to some lesion within the cerebrum, and the prognosis will depend upon the nature of the lesion. If it be of the apoplectic form, as good results may be expected as in a more general apoplectic attack, and the treatment should be given on the same principle. When pseudo-bulbar disease is due to neural

origin, the prognosis is very grave. Here the reaction of degeneration is very prominent, always more marked than in bulbar paralysis, of central origin; the atrophy is also great, and the only benefit that may be expected is the stimulation of the muscles through their motor-points with the interrupted galvanic current.

That form of bulbar disease known as asthenic-bulbar paralysis may be very successfully treated with galvanism. As this paralysis is of functional origin, having no lesion in the medulla, the catalytic action of the current has an opportunity of improving nutrition.

Longitudinal and transverse currents through the mastoid processes and along the sagittal suture should be given about ten minutes. However, care should be taken not to use the interrupted current, or even labile applications of the current, in this form of paralysis. While no reaction of degeneration is present, there is a decreased quantitative irritability which increases rapidly during the application of the interrupted current. The muscles tire under the least stimulation of this kind so rapidly, that after three or four contractions have been made it is no longer possible to produce them, and it requires hours for the muscles to regain their former strength. Here a stabile application of the galvanic current, the positive pole on the back of the neck and the negative on the paralyzed muscles, should be made. The negative may be moved to various points so as to bring the stimulation of the current on the affected muscles, but great care should be taken to decrease the current gradually before removing and replacing the electrode.

Case of Bulbar Paralysis.—Male, age 51. At the time the case came under observation there was atrophy of the tongue and inability to articulate at all clearly. There was evidence of R. D. The orbicularis oris was also atrophied, the mouth was closed with difficulty and could be kept closed but a few minutes at a time. If R. D. was present in this muscle it was very slight indeed. Saliva drooled more or less from the corner of the mouth. Swallowing was very difficult and the most

annoying of any of the symptoms. Treatments were given as recommended in the text, longitudinal currents through the head and stimulation of all affected muscles through their motor points. An electrode was placed on either side of the throat and the current alternated by means of a pole changer. Treatments were given from three to six times a week. At the end of the first month the patient had so improved that the drooling from the mouth had ceased, swallowing had much improved and articulation was slightly better. At the end of the second month improvement ceased, but the patient continued the same until the sixth month, when the disease again progressed and was progressing rapidly at the eighth month, when treatment was discontinued.

DISEASES OF THE SPINAL CORD.—There is no class of diseases in which electro-therapeutics has been longer or more persistently used than in spinal diseases. It has been claimed by some that the electric current is not capable of entering the spine, but there is abundant evidence to prove that it does. The action of the current on the spine is probably from two sources, *i. e*,, the current direct as it is conducted through the foramina and along the blood vessels, and the bombardment of the spinal segments through the peripheral nerves and the nerve trunk. With the first, the galvanic current probably has the greatest penetration, but with the second the higher tension currents are most effective, especially the static spark.

Spastic Paralysis—Primary Lateral Sclerosis.—It is claimed by some, that spastic paralysis is curable in its early stages by the use of electricity. This is extremely doubtful and the more recent reports of cases show that if cures are made it is before the disease has become thoroughly established and therefore a doubt exists as to the diagnosis. However, electricity is very efficacious as a palliative in relieving spasmodically contracted muscles, and in keeping the patient in a state capable of locomotion. As the disease does not tend to fatality but simply to prevent the power of locometion, this palliative effect is much to be desired. Some authors recommend the

use of static electricity. Dr. Ranney claims good results for the heavy static spark. He believes that when it is given over the spine and nerve roots and over the contracted muscles, it is very effective in relieving the contractions. We would modify this treatment. The strong static spark given over the spine and nerve roots undoubtedly exerts a beneficial influence, but our experience has been that when it is given over the contracted muscles, it does not relieve, except in the later stage of the disease, when paresis is marked, at which time its use over the muscles or vigorous faradization will tend to invigorate them. This is especially true of the quadriceps extensor.

Galvanism should by no means be ignored in the treatment of this disease. As the lateral columns are the seat of the degeneration a descending current should be given along the spine for about eight minutes, the strength of current averaging from twenty to twenty-five milliamperes, using flexible hand electrodes of about three inches in diameter. After this the anode may be removed to the abdomen and, with the cathode stabile along various segments of the spine, a current passed for two or three minutes at each segment followed by two or three interruptions. To relieve the spasmodic rigidity the anode should be placed over the contracted muscles,—and here a long, narrow electrode is preferable—and the current gradually raised to its maximum of about ten milliamperes where it should be allowed to remain for two or three minutes, and as gradually reduced. The cathode is retained on the spine. Each muscle or set of muscles should be gone over in this way. Interrupted currents over the motor points should be avoided, except very late in the disease, when paresis has become a dominant feature.

Dr. Steavenson, of London, recommends the electric bath. The patient sits in the bath to which is attached the cathode, the anode being placed on the spine between the shoulders. Treatments are given of ten or fifteen milliamperes for fifteen or twenty minutes. He admits that some cases do not receive benefit from this treatment, and that some are made to feel

weaker after it, but in the majority of cases the patient feels more invigorated, spasms are very much less and locomotion is improved.

Amyotrophic Lateral Sclerosis.—This disease simulates in form that of spastic paralysis, but differs most materially from it, inasmuch as it is rapid in its course and fatal in its termination. Here we have not only a degeneration of the lateral columns, producing symptoms similar to those in spastic paralysis, but also a degeneration of the cells of the grey nucleus of the anterior cornu. In the early stage of spastic paralysis, there is no change in the electrical reactions; later on, however, there is a slight quantitative decrease. The same is true with those muscles in amyotrophic sclerosis that are affected by the degeneration of the lateral columns; but where atrophy takes place, the cells of the anterior horn are affected and here we get reaction of degeneration. The extent of reaction of degeneration, of course, depends upon the amount of destruction of the cells of the grey nucleus.

In this disease only one result may be expected from electrical treatment, and that is a relief of the spasmodic symptoms by the same treatment that is recommended for spastic paralysis, and also a stimulation of the muscles, thus prolonging the locomotion of the patient when the lower extremities are severely affected by muscular rigidity or muscular weakness. The action of electricity is even more marked in this disease than in spastic paralysis, for here we get a much greater weakness in proportion to the stiffness and the treatment helps to overcome this extreme weakness. Whether it assists in prolonging the duration of the disease, and thus prolonging life, is a question which has not as yet been entirely settled, but if it does, its action is slight.

Locomotor Ataxia.—Locomotor ataxia, on account of its frequency, is the most important of the chronic diseases of the spine. It has been studied for many years, and its treatment has been discussed from many points of view. We find oculists curing it, according to their statements, by removing eyestrains, by cutting muscles, or correcting errors of refraction.

The orificial surgeon also claims to cure it by repairing the anal orifice. Others claim to cure it by a system of dry cupping, and so on. There is no spinal disease that has been the subject of so much discussion in the profession, as well as among quacks, as has this one; this is undoubtedly accounted for by its frequency, while the fact, that so many methods of treatment are recommended, proves that none is satisfactory.

The first electrical treatment of locomotor ataxia based upon scientific investigation, dates back to the time of the elder Remak, and since his day this has been the principal remedial agent employed by a great majority of nerve specialists throughout the world. While the results are not as satisfactory as could be wished, the fact that this method has maintained its lead is evidence that the results of other therapeutic measures are even less satisfactory. One advantage of the electrical treatment, that has undoubtedly done much to maintain its position, is that it does not interfere with other forms of treatment; as, for instance, if the primary cause is syphilis, the action of mercury and iodide of potash are increased by the electrical treatment. This statement, we believe, will be borne out by any one who has studied this subject.

Another point in its favor, is that its beneficial action is not limited to the early stages of the disease. To be sure, its best results are obtained in the early stages, but many patients still capable of maintaining their equilibrium, even though walking be with great difficulty, may be more or less benefited by the treatment. After the ataxia has become so great as to deprive the patient of the power of walking, although there may be some improvement manifest, there will not be enough to put the patient on his feet again.

These cases will be better studied by dividing them into four classes.

First, come those which might be considered to be in the stage of congestion, providing we mean that stage where the circulatory change is specific to the beginning of locomotor ataxia and not a simple congestion. This stage is characterized

by the Argyle-Robertson pupil, the loss of the patella reflex, and the lightning pains; but there is no manifestation of ataxia. There is probably very little sclerosis at this stage.

Second are those cases where the ataxia is noticeable, but not enough so as to interfere materially with locomotion, and there are no complications of the bladder or other organs.

Third, is a more severe type, when locomotion is very difficult and the case is complicated by the interference of the disease with the functions of various other organs.

Fourth, come those cases that have completely lost the power of locomotion.

Of fifty cases treated by us, all of which occurred in private practice and do not include hospital or dispensary cases, five were of the first stage, twelve of the second stage, twenty-seven of the third and six of the fourth.

Of these fifty cases those of the first class were apparently for the time cured, so great was the benefit received, but in one case only did the Argyle-Robertson pupil disappear and the knee-jerk re-appear, but that it did exist and disappeared we are sure. Of the second class none were cured, but all were very much improved. The pains were relieved or reduced to the degree that they were quite bearable, and the patients' strength was maintained sufficiently so that they were capable of following the ordinary pursuits of life; and this result was more or less permanent, varying from one year to an indefinite period.

Some temporary relief was afforded to the third class.

Of the fourth class the results were nil.

Erb advises applying one electrode in the sub-aural position, while the other is run up and down the spine. To this he adds labile applications to the muscles of the lower extremities with the cathode, the anode resting on the sacrum. To relieve the pain in the limbs, he applies the anode over the affected nerve where it is given off from the spine, while the cathode is placed over the seat of the pain. He uses a current of medium strength, varying from 15 to 30 cells, probably from ten to twenty milliamperes.

Rumpf recommends daily faradization of all the muscles of the body.

Dr. Frank C. Richardson has reported a number of cases of locomotor ataxia where galvanism has had marked effect in mitigating the symptoms. His method is to use a large sized electrode three or four inches in diameter. He places the cathode over the cervical region. With the anode he begins at the lumbar region and gives stabile currents of fifteen to twenty-five milliamperes for three minutes. The anode is then raised up the spine its length, the current having first been turned off. This segment is treated in the same way and also such succeeding segment until the entire length of the spine is brought under the influence of the current. He recommends treatment two or three times a week.

The method of treatment we should recommend, so far as the application of galvanism is concerned, is to give an ascending current along the spine; the negative electrode is placed on the back of the neck, or in the sub-aural position, as recommended by Erb, and the positive stabile in the lumbar region for ten or fifteen minutes and then transverse through the spine—anode on the abdomen and the cathode stabile on different segments along the spine—the whole treatment occupying about thirty minutes, the strength of current varying from ten to twenty-five milliamperes, given every other day. This treatment is even more effective when the back is painted with iodine before each application. To be sure this will leave the back sore and irritated, but the constant irritation produced in this way assists very much in the relief of the lightning pains.

Static electricity has been used of late, and considerable discussion regarding its merits has been provoked. We are satisfied that it holds a prominent place in the treatment of locomotor ataxia, but the cases in which it is indicated should be carefully selected and promises should not be made regarding its permanent effect.

In order to produce the maximum effect, very severe sparks should be drawn from the spine and roots of the spinal nerves

for at least from three to five minutes; then milder sparks may be drawn from various parts of the body, following down the trunks of the nerves and particularly from the bottom of the feet, where the charges should be concentrated in the form of sparks for two or three minutes. In fact, the treatment of the bottom of the feet, which, by reflex action undoubtedly affects the spine and improves the conductivity of the nerves, has a great effect in temporarily relieving the ataxia.

Regarding the indications for these different treatments to the various stages of the disease which have been given, we consider the first class, or the so-called congestive stage, best treated with galvanism. We have attained better results with it than with any other form of treatment, and in a large proportion of cases in which we have tried static electricity, it aggravated the symptoms, irritated the patients and made them far less comfortable. Occasionally, however, it relieves for the time being the lightning pains.

In the second classification, where there is slight ataxia, galvanism is again the best remedy. Of the twelve cases treated by us in this stage, only three received benefit from static electricity, although it was tried on nine. On the other six it either aggravated the symptoms or produced no change. The results obtained from static treatment of the three cases that were benefited were not as positive as they were with galvanism, which was afterward resorted to.

In the third classification, we believe static electricity is superior to galvanism. In these cases it seems almost impossible to get a good result. We have seen the most brilliant temporary results from static electricity, but the symptoms all returned within a few weeks after the discontinuance of the treatment. Cases of this class are apt to be more paretic but do not suffer the intense lightning pains that afflict patients in the earlier stages. There seems to be a period, about the time the patient lapses from the second to the third class, where there is a decrease of the acuteness of the pain probably due to a more paralytic condition of the sensory nerves;

but the improvement manifested under the static treatment in this stage was in the relief of existing pains and the improvement in the power of locomotion. Its greatest effect is as a stimulant upon the nervous and muscular system, giving the patient more vigor and strength, stimulating his ambition and giving him greater power of resistance.

In the fourth class, we have never used static electricity for the simple reason that we have never been able to get the patients to the office. Therefore it is impossible to determine whether static electricity would be of benefit to them or not.

It is difficult to explain the reason why these different forms of electric manifestation affect various stages of the disease as they do, but it may be that, in the earlier stages, the changes are mostly in the circulation, and that the galvanic current has, by its action on the peripheral nerves and the ganglia of the nerve roots, power to rearrange the circulation and thus relieve the condition In the later stages, when sclerosis has taken place, the galvanic current cannot produce any material effect by its reflex action, on account of its low electro-motive force. With the high electro-motive force of the static charges, the shock given to the nerves produces an impression along the whole course, even to the roots. It bombards the obstruction to the free circulation and helps to establish the normal nerve impulses. At present there is much enthusiasm expressed for the static wave current for long standing cases of tabes. This form of administration promises much. It is of such recent origin that it has not yet established for itself a permanent place, but that it is one of the currents to be considered for the treatment of this disease there is no doubt.

Sperling doubts if any true case of locomotor ataxia has ever been cured. One well-authenticated case, in which all the symptoms had been removed with no recurrence for a period of eight years (until death) proved on post mortem to still have the typical lesion—sclerosis of the posterior columns of the cord—in a marked degree. This fact should not, however, deter us from the use of electricity, as it offers, at present, the only means for ameliorating this affection. The

methods Sperling employs are stabile galvanization of the spinal cord and the use of the faradic brush. The former should be given with a moderate current strength, and but two locations should be treated at one session, same consuming about two minutes. To ameliorate paræsthesia or pains in the limbs, the faradic brush is employed for a few minutes, the affected regions being gently stroked. For the lancinating pains the brush is also employed or during stabile galvanization of the spinal cord, the anode is placed over the origin of the painful nerve while the cathode is placed directly on the nerve itself instead of on the breast or abdomen. In chronic cases, in which the lancinating pains alternate with painful paræsthesias, the current may be increased and prolonged to five minutes, but the anode is then placed on the central terminus of the nerve instead of on the spinal cord. This method is, however, not employed until previous trials have shown the milder applications to have been without result. He believes that labile galvanism of the peripheral nerves in locomotor ataxia, as well as in myelitis, multiple sclerosis and spastic spinal paralysis, is not only useless but harmful.

Hirt claims that an early diagnosis of locomotor ataxia is most important, inasmuch as prompt treatment with general galvano-faradization will check the disease in its incipiency and prevent degeneration, while additional proper hygiene and medication will cure the condition. This pertains to cases in which the peripheral nerves are the first to be attacked. If the lesion commences in the peripheral endings of the cranial nerves the above favorable result is not to be expected. His treatment consists of general galvano-faradization of the whole body, excepting the head. Starting over the spinous processes of the vertebræ, the whole back is worked over with mild or moderately strong currents. In the upper and lower extremities the motor points are irritated and the muscles treated with the galvano-faradic current. The strength of the current must be increased slowly and mildly and daily treatments are recommended for from three to six weeks. After the initial stage is passed, Hirt claims but moderate results

from electricity. The various symptoms may be combated and frequently relieved. but permanent amelioration is not to be expected.

Larat prefers galvanism with short treatments of from 5 to 10 minutes' duration and supplemented with static electricity. Employing a current strength of 10 ma., either electrode is placed at the nape of the neck, the other pole being moved up and down along the apophyses of the vertebral column, and placed at sensitive points along the spine, when those exist. The same method is employed along the course of the nerves of the other affected parts. He usually galvanizes the spine for five minutes and supplements this with static treatment along the same region by means of friction with the wooden ball electrode. The treatments should be given daily.

Combined Sclerosis—Ataxia Paraplegia.—This combined form of sclerosis which attacks both the lateral and posterior columns, naturally partakes of the character of tabes and lateral sclerosis. There is not simply an addition of symptoms, for one tends to neutralize the other so far as pathognomonic symptoms are concerned. The treatment must necessarily be governed by the character of the disease. If the spastic symptoms predominate in the lower extremities as they are apt to, the treatment recommended for spastic paralysis to relieve the spasms and the contractions, should be given. On the other hand, if the ataxic symptoms prevail the treatment recommended for locomotor ataxia should be given. It is customary to give the current along the spine in the direction that the diseased section conducts impressions, but here we have the posterior column conducting ascending impressions and the lateral column conducting descending impressions affected at the same time; therefore, it is better to give both the ascending and descending currents at the same sitting. This is very nicely accomplished by means of a slow alternating sinusoidal current, the alternation not being made oftener than five or six times a minute. If this cannot be had, the treatment may be divided, part of it devoted to the ascending and part to the descending current. There is no doubt that the heavy

static spark given over the spine will exert a beneficial influence on this as well as other chronic spinal diseases. The increased favor with which static sparks are regarded for this class of diseases is marked. The static wave current has also been recommended for combined sclerosis.

Friedreich's Disease—Hereditary Ataxia.—This disease is but little known, yet there have been cases reported which have been relieved by electrical treatment. The relief though, has been only temporary, so far as we have been able to learn. The treatment should always be directed towards palliation of the symptoms, and so varied are the symptoms that it would be impossible to lay down any rule for treatment which will cover all of them. The judgment of the operator must be relied upon. The pathology of this disease is found to be a combined sclerosis of the posterior and pyramidal tracts and should therefore, theoretically at least, be treated similar to the foregoing diseases. The few cases we have found reported, however, for the authenticity of which though we do not vouch, have been treated the same as tabes dorsalis.

Anterior Poliomyelitis—Infantile Paralysis.—We believe there is no organic disease along the entire range of nervous diseases to which electricity is of such universal benefit as poliomyelitis. Of sixty-five cases which we have treated in private practice, all of them in the chronic stage, varying in degree of severity, good results, from a simple increase of warmth to an increase of strength and vigor, were produced in every case. Here we have a degenerative atrophy due to destruction of the cells of the anterior cornu. Reaction of degeneration is always present and its degree gives a very decided clue to the prognosis. Cases of long standing, even of fourteen, fifteen or twenty years, should be treated, for it is quite possible to improve the general circulation and even increase the volume of the limb after this long period. Of course, where the nerve cells are completely destroyed, as shown by the completeness of the reaction of degeneration, it is not possible to regenerate the fibers which have been enervated by those cells, but it is not at all infrequent to find muscles very much atrophied which

have some fibers that are yet capable of stimulation by the galvanic current; wherever this is found, a certain amount of improvement may confidently be expected from systematic treatment.

We have seen a case greatly improved at the age of fourteen years, in which the paralysis occurred in the second year, and in which there had been no apparent improvement for eight or nine years prior to the treatment. If the muscles respond to the galvanic current ever so slightly, the case should not be entirely abandoned, but should be treated daily, or three or four times a week for a month, or even many weeks, when, if the reactions improve, with slight voluntary movement, a continuance of the treatment will probably bring more improvement. These cases are all young and have their lives before them, and any little help that can be afforded them should by all means be given.

A case which has recently come under our observation shows the bad effects of unintelligent treatment. Ten days after the attack, treatment was begun with the faradic current by the family physician. The gastrocnemius and the soleus were the only muscles which responded to the strength of the current used, consequently they were the only ones stimulated. These muscles were made to contract by direct application, and, as the faradic current produces contractions all the time the current is passing, they were kept in a state of tonic rigidity for minutes at a time. Six months after the attack, however, there were modal and serial changes, showing a reaction of degeneration in the anterior tibial, peroneal and quadriceps extensors. To a less degree was the reaction of degeneration present in the gastrocnemius, it only exhibiting a slight modal change, proving that the cells in the anterior cornu of the spine controlling these muscles were not so much affected as were those controlling the others. Yet the gastrocnemius and soleus were as completely paralyzed as any. This was undoubtedly due to the strain the muscles were put under by the earlier electrical treatment, which probably

affected the muscular fibers or intramuscular nerves in such a way as to cause them to lose their stimulative power.

Electricity should be used upon the muscle only for diagnostic purposes in the early stage, and then with caution. The application of galvanism to the spine in the early stage should not be made until the temperature has returned to the normal and remained there for from five to eight days. Electricity is generally looked upon as a remedy to be brought into use after all other remedies and proceedings have failed. This has been particularly the case in infantile paralysis—to stimulate the muscles—but has been overlooked in its possible action to arrest the process of destruction in the central lesion and thus prevent, to a degree, the bad after-effects.

The best method of application at first is to place a spinal electrode—one long enough to cover the diseased area and broad enough to take in the nerve roots—over the seat of the lesion and to this attach the positive pole, the negative being placed on the abdomen. The current is gradually raised to five or eight milliamperes for five minutes, when it is gradually reduced. After two weeks' treatment, every other day, the polarity may be reversed,—*i. e.*, negative on back and positive on abdomen,—and the current strength increased to ten or twelve milliamperes. Still later, alternations may be made with the electrodes in the same position, thereby giving greater stimulation to the spine.

After the disease has progressed to its chronic state, that is, after the reaction of degeneration begins to grow less, or, at any rate, ceases to grow worse, and the acute progressive stage of atrophy has passed, active electrical treatment should be given on the muscles; at first labile applications may be given over the muscles, but after a week or two, treatment should be given over the motor points with the interrupted galvanic current until numerous contractions have been produced. The rapidity with which these contractions follow each other is important. Too rapid interruptions fatigue the muscles, which, after the first few contractions, grow more feeble. Not more than twenty or thirty per minute should be

made, and in the early stage, when the muscles are very weak, it is best to cause but few contractions at a time, treating other muscles from time to time and then returning to the first ones stimulated. The pole selected for use on the motor points should be the one which causes the greatest contractions, as it is quite possible that the positive may produce more powerful stimulation than the negative. The strength of current should also be governed more by the power of contractions and what the little patient can be made to bear than by the number of milliamperes. Sometimes it will be found impossible to produce contractions at all by this method. When the patient is of an age that he will bear a stronger shock, contractions may be produced by placing one pole over the motor point and the other a little above; or one pole may be placed at either end of the muscle and the current reversed by means of a pole changer.

Why the faradic current is recommended for the treatment of this disease is incomprehensible, for, in the first place, it is more disagreeable, which is a very important factor in the treatment of children. A still more important point is that the muscles in which the faradic irritability is decreased, even if it be not entirely lost, require such a strong current to produce contractions, that, by reflex action or by leakage of the current to other nerves, even strong contractions of an opposite healthy muscle may be caused, and the deformity thereby increased instead of decreased. The principal objection, however, is the inferiority of the faradic current to the galvanic in improving these muscles.

It may be difficult at first to overcome the child's fear of the treatment, but this can always be done with a little patience and diplomacy. Even if the first treatments are not of sufficient strength to be of any use, you gain the confidence of the child and will have no trouble in getting him to bear the current sufficiently strong.

As soon as voluntary movement is noticed, it should be encouraged by the patient willing the muscle to contract. This may be done twice a day at first, but, after the muscle in-

creases in strength, it should be practiced several times a day; the parent or nurse should remind the child of it, or he will be apt to neglect it.

The deformity in these cases is due either to a contracted fascia, or to a contraction of a strong muscle or a group of muscles which act in opposition to the paralyzed ones. If the fascia is contracted to any considerable degree it should be cut. With a contracted muscle, it depends upon the degree of shortening. If the contraction is slight, so that the deformity can be reduced by slight pressure, a properly fitted brace may be supplied to support the paralyzed muscles and keep the deformity reduced. If, however, the contraction is so great that slight pressure fails to reduce it, tenotomy should be performed.

Progressive Muscular Atrophy.—This disease of adult life, originating in the grey nucleus of the anterior cornu of the spine, is one of the diseases in which nearly all the authorities agree that electricity is one of the best therapeutic remedies. There is one notable authority who disagrees with this conclusion and that is Gower. There appears to be a disagreement among writers as to the occurrence of the reaction of degeneration in this disease. There should, however, be none, for the difference is simply owing, as Erb has pointed out, to the peculiar anatomical distribution of the pathological process. The cells of the anterior cornu degenerate cell by cell, and consequently the muscles degenerate fiber by fiber. If it were possible to pick out those fibres which had atrophied to a certain degree and separate them for an electrical test, reaction of degeneration would be present. But in testing a muscle as a whole, those fibers which have not yet been affected respond in a normal manner, and as they respond more vigorously than the atrophied fibers, they completely mask the reaction of degeneration which is actually present in the diseased fibers. It is claimed that by using a very small electrode reaction of degeneration may be discovered in the bundles of atrophied fibers. However, after numerous attempts we have invariably failed in this test.

The truth is, that very little change takes place in the elec-

trical reactions in a muscle where a certain proportion of the fibres remain intact. A muscle half atrophied will only show a slight quantitative decrease, but as the atrophy continues and all the fibers or nearly all have become affected by the progressive degeneration, reaction of degeneration becomes manifest. This also gives a clue to the prognosis, for when reaction of degeneration is marked in a muscle, it is impossible to restore that muscle. The earlier the case comes under treatment the better the result. Many cases have been reported in which the atrophy has permanently ceased to progress spontaneously, but it appears that this seldom takes place until atrophy has progressed to a very considerable extent. There is no doubt that careful treatment has a decided effect on the progress of this disease and many cures have been effected by treatment. Two cases which were treated by us, one seven years ago with faradism, and one nine years ago with galvanism, have remained well. The muscles atrophied in both cases were in the forearm and hand. The marks of the atrophy are still present, but there has been no increase of it for the years mentioned, and instead, by development of the remaining muscular fibers, the arms and hands are much stronger than when treatment was discontinued. It is true, however, that many who have been apparently cured have relapsed, even though the treatment was continuous through the apparently regenerative period.

The greatest success has been attained in those cases where the forearm and hand have been the seat of the disease. When the arm, shoulder, face and neck are involved, the prognosis is less favorable, except, perhaps, to prolong the patient's life and to maintain his strength.

Ranney believes that the strong static spark given over the spine and over the affected muscles is the best method of treatment. Morton concurs in this, but recommends that a lighter spark be given over the muscles than over the spine. We have very recently seen one apparently excellent result from the static wave current, but more time will be required to arrive at definite conclusions. Duchenne, who studied this

disease carefully, had most excellent results from faradization alone. He recommended as an adjunct to the faradic treatment the placing of the positive pole of the galvanic current over the diseased spinal segment with the negative over the affected muscles. He depended almost entirely upon faradization, however. There is no question but that he was prejudiced in favor of the faradic current, and he is not, therefore, to be taken too seriously in his enthusiasm for that form of treatment. Erb recommends the application of the galvanic current to the spine, and thinks it must play the chief part in the electrical treatment. He also believes that galvanization of the cervical sympathetics should be included in the treatment. His method of galvanization of the spine is the stabile application of both poles alternately with moderately strong currents to the diseased parts ; in addition he gives moderately strong galvanic or faradic currents to the neuro-muscular tract.

The best method which we have ever tried is to give a moderately strong current transversely through the spine, the anode with the flexible hand electrode, three or four inches in diameter, placed over the diseased segment, and the cathode over the sternum. Stabile treatment of about fifteen or twenty milliamperes should be given when the anode may be moved its length and so on until all the diseased sections of the spine have been included, the entire treatment lasting perhaps ten minutes. So far as the local treatment to the muscles is concerned, we have found benefit from faradization in three different cases where galvanization has failed to produce results. The current of tension should be used and a current given strong enough to produce firm contractions when the electrode is rapidly moved over them. However, strong clonic contractions should be avoided, for that is sure to tire the muscle. This application may last five to ten minutes more, according to the number of muscles affected. The static spray which is recommended by some to take the place of the faradic current is, according to our experience, inferior to it.

Pseudo Muscular Hypertrophy.—This disease of childhood has not been well understood from a pathological point. Whether its primary seat is in the muscles or in the spine seems still to be a disputed question. In fact, some claim that certain cases originate in the spine and others in the muscles; clinically it is veiy difficult to make this distinction. The reaction of degeneration is not present in this disease and it is seldom, except in the very last stages, that there is a marked quantitative decrease. Whether the interstitial fibrous deposit which takes place within the muscle irritates the intermuscular nerve fibers so that they respond very readily to the electric current is a question; at any rate, for the extreme amount of atrophy which takes place, there is less quantitative decrease than in any other disease with which we are acquainted. Here again Duchenne, as usual, recommends faradization of the muscles and claims excellent results. Hammond, however, is emphatic in his recommendation of galvanization of that segment of the spine which supplies the diseased muscles in conjunction with faradization of the muscles as recommended by Duchenne.

The most successful treatment we have found is similar to that given in progressive muscular atrophy, a transverse current through the spine with the anode on the back and the cathode over the abdomen. In this disease we have often reversed the current several times and so hypersensitive are the spinal centers, or nerve-roots that with one electrode over the lumbar region, the reversal of the current will produce contractions of all the lower extremities. After this, labile faradization of the muscles, the same as in progressive muscular atrophy, may be given. While electricity is about the only therapeutic agent known to-day for this disease, and while it has often produced beneficial results, and prolonged life by holding the disease in check, it is a question whether a case has been entirely cured by it. We have, however, had under observation now for four years, a little boy, who, although the disease was advanced when he came under treatment and the treatments have not been given with the greatest of regularity, still ap-

pears to hold his own or nearly so. During that period he has been able to keep in school, learns easily, and has grown about as rapidly as a healthy boy. In one other case which we have seen, the natural progress of the disease has been checked, but how long this may continue and how permanent may be the results is a question for further observation.

Disseminated Sclerosis—The variety of symptoms that the disease here designated has given rise to and the different locations of pathological lesions, make it impossible to give any set rules for the electrical treatment.

In treating the posterior and lateral columns of the spine one rule should always be the guide, and that is to conduct the electrical current in the same direction as the diseased column conducts impressions, upward in the posterior and downward in the lateral. This rule, however, does not apply to the anterior cornu. When the cornu is the seat of disease, transverse currents should be given through the diseased segment or section. These rules, it must be admitted, are empirical, based only upon clinical experience. It has not been our lot to accomplish anything definitely by the application of electricity to the spine for disseminated sclerosis. About the only benefit that can be effected here is to strengthen the muscles by giving them active exercise with the interrupted galvanic current over the motor points, or perhaps better still, with the sinusoidal currents. Some recommend that the static be given in strong sparks over the muscles and over the spine. If muscular contractions are produced by the static spark, it has a similar action but much less than the galvanic current. The tremor in disseminated sclerosis is mitigated very little, if any, by the application of the galvanic current. From a physiological standpoint it should be administered by giving stabile anode applications over the diseased nerve trunks. This is, however, according to our experience, not worth the trial.

Spinal Hyperæmia and Anæmia.—It is a question whether these diseases exist in a way in which they can be diagnosed for treatment. That form of so-called anæmia known as irrita-

tion of the spine, and which is supposed by many to be due to an anæmia of the posterior columns, is treated of in this volume under neurasthenia, as we believe it is a manifestation of that disease. For a simple congestion or anæmia of the spine Lowenfeld recommends applying the anode at the neck and the cathode stabile on the lumbar region to relieve congestion, and the reverse to relieve anæmia. Naturally the faradic brush given over the entire surface of the body, or active treatment over the muscles so as to produce contraction of them, would draw the blood from the spine into the periphery. These remarks are made here as it might appear that a work of this character would be incomplete without them, and not because there is a clinical foundation upon which to base them.

Spinal Meningitis and Myelitis.—Electricity is not indicated in any form in the acute stages of these two diseases, but after they have run their course there is generally a condition remaining, varying from a complete paralysis to a simple numbness, which may be benefited by electrical treatment. In a general myelitis affecting the entire section of the cord, reaction of degeneration will be present in those muscles supplied by that section, otherwise only a slight quantitative decrease, or perhaps at first a quantitative increase, may be manifest. When reaction of degeneration is present following a case of meningitis, it is proof that the inflammation has reached the nerve roots, and that there is more or less degeneration of them. The principle of treatment here should be governed by the general rules. First, pass a current directly through the diseased part of the spine with the cathode on the back, the anode in front; also ascending and descending currents should be given accordingly as there are changes in the posterior or lateral columns. However, this treatment should be governed by the conditions present. If anæsthesia exists the faradic brush should be used. If there is paralysis, labile applications or the interrupted galvanic current should be given over the motor points. The latter should always be used when reaction of degeneration is present. Treatment should

not be begun until all signs of inflammation have disappeared. It should at first be given with caution, using not more than five milliamperes and gradually increased to fifteen or even up to twenty-five if the patient bears it well. The spinal treatment should occupy about ten minutes and the peripheral treatment ten more. Prognosis will be governed by the conditions present, but in nearly every case more or less strengthening of the paralyzed parts and relief of the annoying symptoms may be expected. The sphincters of the rectum and of the bladder, which are paralyzed when there has been a myelitis, should receive local treatment. With a small electrode the sphincter of the rectum may be made to contract, the same as the muscles of the extremities. Into the sphincter of the bladder a large steel sound, as large as the urethra can take, should be introduced; to this is attached the cathode of the galvanic or one pole of the faradic; the former, however, is preferable, but should be handled with care and no electrolysis should be produced. The paresis of the bowels should also be treated in a similar manner, but for this the reader is referred to the treatment of constipation, as there it is given in detail. The static spark has been highly extolled for these conditions. Some recommend a strong static spark over the spine and over the peripheral region which is affected. Others claim that the breeze is preferable. When the reaction of degeneration is present, showing that the anterior cornu or the nerve roots are affected, the static spark will not be of much use, but, as will be seen in the article on anæsthesia, the static spark is most beneficial in treating that symptom. Therefore, when the posterior column is largely the seat of the disease, static treatment will undoubtedly be of great service.

Spinal Apoplexy.—This is a very rare disease. The character of its manifestation, of course, differs according to the location of the hemorrhage. The same is true of the reactions; if the hemorrhage be in the grey matter of the anterior cornu, reaction of degeneration will be present to a greater or less degree, according to the amount of destruction at that point;

otherwise the changes in reactions will not be typical. First, pass a current through the section of the cord where the hemorrhage has taken place. This may be begun much sooner than in cerebral hemorrhage; a week or ten days is sufficient time to elapse. The treatment of the peripheral nerves should be the same as spinal meningitis or myelitis. If anæthesia exist, the faradic brush may be used. The static spark has been very highly recommended, but the rules governing it should be the same as those given for spinal meningitis or myelitis.

Ascending Spinal Paralysis.—This disease is of uncertain origin, varying in its mode of onset and in its manifestations, and ofttimes must be treated according to these variations. No reaction of degeneration is present. The method of treatment which has been recommended is to pass an ascending or descending current along the spine, so that it may affect the posterior or lateral columns; the peripheral treatment as given in spinal meningitis and myelitis has also been recommended. We cannot speak from experience of this disease.

FUNCTIONAL NERVOUS DISEASES, GENERAL NERVOUS DISEASES AND NERVOUS DISEASES OF UNCERTAIN ORIGIN.—EPILEPSY.—If any other treatment was successful in epilepsy, electricity would not be mentioned in this volume. The electrical treatment is not successful in epilepsy as we nowadays reckon success, but in such a grave malady, that incapacitates and makes miserable the life of the patient, any therapeutic measure which holds out the least prospect of relief should be known. Some cases, however, have been reported as cured by electricity and scores of others as relieved to a greater or less degree, but these are only a small percentage of the large number which have been treated by this agent. There seems to be a uniformity of opinion that whatever success has been achieved depends upon cephalic galvanization; the only difference of opinion on this point is as to the method of application of the galvanic current to the head. Erb recommends also general faradization but lays the greatest stress upon cephalic galvanization. Some of

the successes have been attained by passing the galvanic current through the motor centers of the brain in the neighborhood surrounding the fissure of Rolando; others have achieved success by passing the current transversely through the temples; while still others have passed it in every conceivable direction. Erb, as usual, however, gives very specific directions. He advises placing the cathode on the nape of the neck and the anode on the side of the forehead, passing a weak current for about one minute, and then, bringing the anode to the forehead and cathode to the occiput, giving the same current in strength for the same length of time. Some authors, notable Althouse, recommend galvanizing the seat of the aura. This is, as a rule, in the abdomen, and may be easily brought under the influence of the cathode in central galvanization, while the effect of the anode is exclusively on the head. Some cases have been reported cured by this method of treatment.

We have succeeded in greatly relieving a child eight years old who had convulsions for three years, varying from eight to fifteen every twenty-four hours. These were all of the petite mal variety with the exception of one grand mal which occurred regularly about four o'clock every afternoon. Occasionally another grand mal would occur, usually in the evening about nine o'clock. The method of treatment was to apply a large electrode made of lead covered with absorbent cotton; this was made to conform to the entire head, coming down as far as the ears and reaching from the forehead nearly to the occipital protuberance. To this was attached the anode, the cathode being placed either upon the spine or on the abdomen, and a current of about five milliamperes given for as many minutes every other day. The petite mal gradually lessened in frequency until only two or three a day were noted, while the grand mal decreased to about one in two weeks. The treatments were continued for nine months. The case has been under observation for four years since discontinuing treatment and there seems to be no tendency of a return to the former condition. The positive pole here was

used on the head empirically, based on clinical experiences that the anode seems to stimulate the cerebral mass more than the cathode. However, other cases of much less severity than this one have shown no apparent improvement after receiving the same treatment. Another case is a young man, aged 33, who had convulsions every other week with remarkable regularity, and was apparently very much benefited by static sparks over the occiput and down the entire length of the spine. They were reduced to one in four or six weeks. The case was lost sight of soon after discontinuing treatment.

Chorea.—Chorea is often a self-limited disease, and it is therefore difficult to say just how much benefit any form of treatment may give, but the marked results frequently following electrical treatment are so apparent that there can be no mistake regarding its efficacy. These results are not only noticeable in recent cases, but in the more chronic forms as well, and also in the severer types where medication has been tried and failed. The prognosis, however, regarding the effect of electricity, should be governed by the same conditions which govern prognosis in general. Electricity is most useful in those cases which are accompanied by anæmia or follow some acute disease, such as rheumatism. It is not so important that this treatment should be given during the first week or two of an acute attack, but as a rule the earlier it is given the better. Erb says that the beneficial results of electricity are due largely to its tonic properties, and recommends general faradization. He also recommends, but with apparently not much hope of success, galvanization of the cerebral motor centers. This is best done by placing the anode over the region of the fissure of Rolanda, with the cathode on the neck of the opposite side. Others claim that static electricity is best for treating this disease, while still others combine both the galvanic and static. Static electricity alone certainly has a marked beneficial effect in a large number of cases. It should, however, be very carefully given. The best way is to begin simply with negative insulation only, allowing the charge to go off the body through the hair and other points.

Care should be exercised in administering even this form, as a little too strong a charge or an accident in allowing a spark to pass, will be sure to increase the choreic movements. After the patient has become accustomed to electrical treatment, it will be noticed that choreic movements occur less during the application. After a few such treatments a gentle static breeze may be given and gradually increased from treatment to treatment as the patient becomes accustomed to it. The sparks, however, should never be used until the patient has nearly recovered, but the static breeze along the spine may be given as soon as the patient has become accustomed to it, when a child is the patient, and from the beginning, when an adult is the patient. Gower says that a galvanic current given along the spine decreases the choreic movements during the treatment, but he doubts whether it has any permanent effect.

The galvanic current should certainly play a very important part in the treatment of chorea. Riggs recommends passing a longitudinal current through the head, giving two or three milliamperes for as many minutes, and then along the spine giving ten milliamperes for seven or eight minutes. This he combines with the static treatment. We have had most excellent results in giving first central galvanization followed by the static as recommended above. We would also recommend Riggs' method combined with the static treatment. During the first treatment there may be apparently a slight aggravation. This is owing to the nervous condition of the patient and the fear of the treatment; however, with due care not to shock or distress the patient during the treatment this will disappear and as before stated the choreic movements will be less during the time of application.

That form of persistent facial chorea which lingers so often after an acute attack, and those forms of choreic movements of the face which may appear independent of any attack, Riggs claims, may be benefited by strong treatment with the faradic current, gradually increasing to the point that it slightly fatigues the muscles. It will be found that medication often fails to produce a complete cure in acute attacks, leaving cer-

tain habitual movements after the principal symptoms have disappeared. In these cases the static spray given over the spine will cause them to disappear in a week or two. That form of choreic movements in adults, which is so persistent and baffles all kinds of treatment, is not successfully treated by electricity. We once experimented on two cases, brothers, twenty-eight and thirty years of age respectively, suffering with this affection apparently hereditary, as their father had suffered with it. So long as one or both poles of the galvanic current were on the head or spine the choreic movements would cease, but they would recur within thirty minutes after the current was turned off. It mattered not whether one pole or both was on the head or spine. One pole on the spine and the other on the front of the chest would quiet the choreic movements at once, but when the current was passed through the chest in the other direction it had no effect upon the movements. Neither did the strength of current appear to be important; a very weak one, a medium one, or a strong one, all seemed to have apparently the same effect. However, after persistent treatment not the slightest benefit in a permanent way was noted in either case.

Cohn recommends local galvanization of the parts affected with weak currents, three milliamperes, the cathode being placed in the jugular fossa, the smaller anode (well moistened) being moved over the affected parts.

Galvanization of the sympathetics of the neck is also efficacious. The anode is placed beneath the lobule of the ear posterior to the descending ramus of the jaw, the cathode is located at the jugular fossa and a current of from one to three milliamperes of a few minutes' duration is employed. The cathode may be placed on the opposite side at the jugular fossa, or in the region of the transverse processes of the lower cervical vertebræ.

Paralysis Agitans. Electricity has been recommended in this disease to keep up the nutrition of the muscles, but in fact the tremor itself by the exercise of muscular fiber keeps them very well nourished. However, it might be used in such a case

by passing a stabile galvanic, or even a faradic current, through the muscles. An interrupted galvanic current is never indicated. We have treated ten cases of paralysis agitans with electricity, with the result of total failure in every case. We galvanized the head, galvanized the spine, gave general faradization, static insulation, static breeze, static spark, in fact, every known form of static application and aggravation has been the result far oftener than relief. One very curious coincidence has occurred in four cases when galvanization of the spine was tried; it produced a decided irritation of the bladder causing frequent urinations, and this would come and go with the continuance and discontinuance of the treatment, proving that whatever might be the modus operandi of its action, galvanization of the spine was the exciting cause of the vesical irritation. According to some observers central galvanization has been used successfully in recent cases; in chronic cases but little can be achieved, although the painful sensations in the rigid muscles, insomnia and anorexia might be relieved by proper electrical application. The tremor and uneasiness of the muscles might also be allayed to some extent. Charcot recommends the static breeze with an occasional discharge of sparks; this he states acts especially well on the tremor.

Larat reports using the high frequency current and static spark in a case of paralysis agitans with marked amelioration of symptoms but does not presume to venture an opinion on its merits from this single case. Further application will be required to determine its value. The same author finds the vibration treatment as recommended by Charcot, combined with static electricity, palliative in many cases.

Athetosis.—The first case of athetosis described by Dr. Hammond was not benefited by electrical treatment, but it was afterwards benefited by stretching the nerve. In more recent cases electrical treatment has been of decided benefit; in fact, it is about the only reliance in many cases. Even Gower cured a case with galvanism, or at least galvanism must have played the most important part in its cure. He used the descending galvanic current, the anode on the back

of the neck and the cathode on the affected muscles, and also on the hands and feet. Erb relieved one case by galvanizing the head and sympathetics, afterwards giving a descending current down the limb the same as Gower. This form of treatment appears to be the most successful. As this condition is very apt to be the result of some brain lesion it is always better to first galvanize the head, together with galvanization of the cervical sympathetics. Then pass a descending current down the affected limb, placing the anode over the segment of spine from which the nervous irritability is supplied to the affected muscles and nerves, and with the cathode give both stabile and labile applications over the part which is affected.

Sperling recommends central galvanization and labile galvanic treatment of the affected extremities. We cannot speak from experience in this disease as we have never had occasion to treat a case.

Tetany.—This disease of childhood, characterized by twitching of groups of muscles, is quite successfully treated by electricity. The reactions are so characteristic that they are often used to diagnose tetany from hysteria, chorea and other allied affections. Kusmaul and Erb claim that there is always a quantitative increase of irritability both to the galvanic and faradic current. More recent observers, however, have claimed that this increased irritability is not always present even to the galvanic current—although there are a few exceptions—but that there are many cases in which it is not present to the faradic. There may have been a mistake in diagnosis in some of these cases. That the irritability is greatly increased to the galvanic current so that tetany is easily produced, there is not the least doubt, but it is very evident to those who have studied the electrical reactions in this disease to any extent that an increase of electrical excitability is more marked to the galvanic than to the faradic.

There are two indications for electrical treatment in tetany. The first is to build up the general nutrition of the patient. This is best accomplished by giving the static breeze, or gen-

eral faradization. To this should be added galvanism of the affected parts. The spasms are very much relieved when the galvanic current is applied to them without respect to the pole used. On general principles, however, the anode should be applied over the nerve trunks, or what is even better still, a very large electrode which will cover the group of affected muscles might be employed. The cathode should be placed on the cervical spine if the upper extremities are involved, and on the lumbar regions if the lower extremities are involved. The current should be gradually increased and gradually decreased. This will generally remove the spasm for the time being. Afterwards labile applications of the cathode to the affected group of muscles should be given.

We have had a case which was of six months' standing relieved within two weeks after beginning the treatment, which was given every other day. The strength of current, of course, varies with the patient; generally about eight or ten milliamperes may be given.

Tetanus.—There has not been the best of results in the electrical treatment of tetanus. Experience in the disease has been limited, however. Mendel, of Berlin, has reported two cases cured. His method was to place the cathode on the spine and the anode stabile over the spasmodic muscles, gradually increasing and gradually decreasing the current. This will relax the muscles, as we have demonstrated in one case, but the effect is far from being continuous; in fact, it returned in thirty seconds after the discontinuance of the application. There have been other cases reported cured, but in most of them other treatment has been used in connection with the electrical. It is difficult, therefore, to say just how much permanent benefit resulted from the use of the galvanic current.

Torticollis—Wry Neck.—In order to more fully understand the electrical treatment of torticollis it is necessary to consider the affection under four divisions. First, is that of rheumatic origin, which is very promptly relieved by electrical treatment. Second, torticollis of hysterical origin, which is also very

promptly relieved. In the third division there are those cases which begin in a tonic contraction and eventually result in a tense contracture with shrinkage, tenderness and hardness of the muscles. The pathology of this form of torticollis is uncertain, probably varying with different cases; the prognosis is therefore necessarily uncertain. To the fourth class belong those cases which are undoubtedly of central origin and which are characterized by a specie of tremor or agitation, and which differ from the tremor of sclerosis, as they are uninfluenced by attempts to control it on the part of the patient. In five cases we treated belonging to the fourth class, there were negative results so far as permanency was concerned, but the spasms were invariably relieved temporarily by a passage of the galvanic current through the muscles. It mattered not what was the direction of the current or which pole was used upon the muscle.

In recent cases the electrical reactions are not materially changed. In very chronic cases, however, reactions of degeneration have been noticed in the diseased muscles with a diminution of excitability in the muscles of the opposite side, probably due to the strain the contracted muscles were constantly putting upon them. Those cases of a rheumatic origin should be treated the same as muscular rheumatism, to which the reader is referred. However, we may say here that the treatment consists in placing the anode over the back of the neck, and giving labile applications of the cathode along the affected muscles. The faradic current may also be employed. In fact, it will be found generally, that if one current does not particularly benefit the patient, the other will. Static electricity in the form of sparks or breeze may also be given with assured success. This treatment will also suffice for the hysterical variety of torticollis.

Dr. Alexander McLane Hamilton devised a very ingenious form of treatment that has been the most successful we have ever employed. He used both the galvanic and faradic currents. One electrode, to which is attached the anode of the galvanic and the cathode of the faradic, is applied on the back

of the neck; the galvanic cathode is placed over the region of the affected muscle and the anodal faradic, attached to a third electrode, is placed over the weakened muscle opposite. It is necessary to give about seven or eight milliamperes of the galvanic, and of the faradic sufficient strength to produce contractions of the weakened muscle.

Some authorities have recommended vigorous faradization with the electric brush. This might be of service in the rheumatic and hysterical forms, particularly the latter. The static spark, it is claimed, has produced wonderful results on the contracted muscles, but we have failed to verify this; on the contrary, we have had negative results.

Neuroses Due to Occupation.—Under this head are classed all those diseases in which there are located affections of special groups of muscles or organs, which have become diseased owing to excessive use in some occupation. The blacksmith's arm becomes paralyzed, the book-keeper is unable to use his pen, the pianist is unable to manipulate the keys, the violinist and harpist can no longer thumb their strings, the telegrapher is unable to work his instrument, the danseuse loses control of her feet, the auctioneer is unable to use his voice, and the singer finds his notes failing him. In all these cases over-exertion of the respective organs is the basis of the troubles which thus exhibit themselves in motor disturbances. These are followed by a feeling of heaviness, pain and paræsthesia, with subsequent cramps or twitching of the affected organs, and the disease reaches the stage designated respectively as writer's cramp, pianist's cramp, telegrapher's paralysis, etc.

It is one of the most obstinate forms of diseases known to the physician, having a very uncertain pathology and uncertain prognosis. The only thing actually known regarding it is its etiology. The electrical reactions of this disease are varied. In some cases there is a decrease, and in still others there is reaction of degeneration. Ross claims that when irritability is increased, the seat of the disease is in the cortical substance of the brain and when it is diminished or reaction of degeneration is present, it is in the ganglion cells of the spine. Others

claim, that the increase of irritability is in the earlier stages, while the decrease of irritability and reaction of degeneration are present in the later stage. Still others claim that the increase of irritability is due to an active neuritis, the decrease of irritability following the subsidence of the neuritis, and that when reaction of degeneration is present there has been destruction of or pressure upon the nerve fibers. It is generally admitted that the faradic current is of no use in this disease. On the supposition that artisan's paralysis was due to an over-sensitive condition of the nerves, a descending current was applied along the arm, and stabile applications made over the spasmodic muscles, great care being taken not to produce interruption, thus avoiding contractions. Others have on the contrary advised strong labile applications of the galvanic current.

Out of twenty-six cases,—twenty-two writer's cramp and four telegrapher's paralysis,—which we have treated, there was noticeable relief in only three of the writer's cramp under treatment with galvanism, and these were in the early stage where the hand tired easily, and the spasms did not make their appearance to any great degree until the hand became tired. The treatment was rest, massage and galvanism applied by labile applications with the cathode over the muscles and the anode stabile over the cervical spine. In two cases, however, relapses occurred and developed into a complete case of writer's cramp. In six cases after galvanism had failed, marked benefit was produced by the strong static spark given over the upper region of the spine, shoulder, arm, forearm and hand. The static was not tried in the first fourteen cases as they occurred some years ago, before static electricity was much used. It was tried in twelve and succeeded in relieving one-half of the number, but in no case could it be claimed that a cure was made, as in two, which were apparently cured, the symptoms returned in a few months after return of the patients to their work as bookkeepers.

De Watteville recommends in conjunction with galvanism, Ross's gymnastic exercises which is to exercise three or four

times daily with the affected extremity, the hand being opened and closed in quick succession, the number of movements being increased until a half hour has been attained for each sitting. Passive exercises of the muscles in which forcible contraction is made by the operation three or four times a day upon each of the affected muscles separately, applying the traction in the direction of its length, is also recommended. De Watteville mentions labile cathodic galvanization of the brachial plexus and of the muscles and nerves of the arm, the anode over the cervical enlargement, using but a mild current.

Poore, who has studied this disease carefully, recommends two plans. One is to place the anode in the axilla and the cathode over the ulnar just above the olecranon while at the same time the patient is made to separate and approximate the fingers rhythmically. His other plan of treatment is to place the anode over the median nerve at the inner border of the biceps and the cathode over the body of the flexor longus pollicis, the patient at the same time rhythmically flexing the distal phalanx of the thumb.

Vigouroux has successfully employed the static charge as an adjutant to massage of the affected parts in many cases of professional neuroses. Massage must be persistently and properly applied to be of avail.

Monnell has reported good results with static treatments.

It must be admitted that the various methods recommended are proof that none of them is very satisfactory.

Migraine—Sick Headache.—The pathology of this disease is still uncertain. It may be a periodical functional neurosis or it may be a vaso-motor neurosis. It is possibly a hyperæmia or an anæmia of the brain, or it may be due to a local lesion. A disease of such uncertain pathology certainly has an uncertain prognosis. This is shown by the great variety of treatments that have been instituted for it. There are scarcely any two writers who agree on the electrical treatment of it. Althouse derides the faradic current, claiming it is of no use, while Frommhold recommends it and Bartholow thinks well

of it. The cases which will be benefited by electrical treatment must be very carefully selected. It is always well to first correct the diet and habits of the patient. If there are eye defects they should be corrected. Polypi and other growths in the nose should be carefully looked after. Heredity undoubtedly plays an important part in this disease and should be taken into consideration in the prognosis. If after all these discoverable defects have been corrected, the digestion made good and the bowels regular, the sick headache continues, electricity may be of decided benefit. Those cases in which it seems to act best are where the general constitution is reduced, where the patient is anæmic and neurasthenic, and the nutrition is at a low ebb; it has less effect in well nourished or plethoric individuals. It is not safe to lay down rules for any one method of electrical treatment. While the galvanic current will perhaps relieve more cases than any other form, it will often be found that after that fails the faradic will prove very beneficial. In still other cases where both have failed the static spray over the head may be beneficial. It is not often that much will be accomplished with electricity in cutting short the attack. If the galvanic current applied through the head or over the sympathetics of the neck relieves the pain for a certain length of time, and after repeating the application the relief is for a longer period, the prognosis is very favorable so far as relieving the attack is concerned; one or two more applications will be all that is needed. But if the second period of relief does not continue longer than the first, it is useless to continue treatment for any immediate effect. For the permanent cure or relief of migraine, treatments should be given regularly two or three times a week between the attacks. Althouse recommends passing the galvanic current through the temples and mastoid processes. Others recommend galvanism of the head and the sympathetics with the anode, the cathode covering the spine or epigastrium. Others recommend strong faradization, one pole over the epigastrium and the other over the head and upper spine. General faradization is certainly indicated in those who suffer from

anæmia. Static electricity has scored wonderful successes in this disease. Riggs recommends it very highly for the anæmic form. He applies the electric breeze or spray to the head of the patient by means of a pointed brass electrode, playing it especially over the painful area and cervical sympathetics. With this he uses central galvanization, or sub-aural galvanization for what he terms the hyper-anæmic. He uses simple insulation with the static for its tonic effect. Many cases have been reported where a prolonged course of treatment by the electrostatic breeze or spark has produced complete immunity from attacks. These cases were probably of a neurasthenic origin. An electric bath where the patient is placed in water which serves as a medium for conducting the negative pole, the anode being over the head, neck or spine, has been very highly recommended. The truth is, that no one treatment will apply to all cases. The treatment must vary according to the conditions. If after two or three treatments no improvement is noted it should be changed to another form, always, of course, following along the line of certain well known indications, which must be based on the physiological action of the current.

Mueller's (Wiesbaden) treatment for spastic migraine consists in applying the anode to the neck, the smaller cathode along the sympathetics of the neck, starting along the anterior margin of the sterno-cleido-mastoid muscle with a current strength of two to three milliamperes. The treatment lasts three minutes. One day the right sympathetic, the next day the left sympathetic is treated. A case of forty years' standing was thus cured in five months. Mueller leans to the theory that migraine is due to disease of the sympathetic nerve. Patients suffering from migraine, according to him, should also receive psychological and dietetic treatment, suggestive therapeutics often relieving the condition in a surprising manner.

Neuralgia.—In the treatment of that form of neuralgia due to a purely functional derangement of the nerve without any organic lesion, electricity is, as a rule, very successful. Facial

neuralgia is not so successfully treated as some other forms, owing to the deep seat of the nerve, with its bony coverings, thus making the resistance so enormous that it is difficult to concentrate the current upon it. Next in point of failure, comes brachial neuralgia. Probably the neuralgia most successfully treated by the electric current is intercostal.

All currents are indicated in various stages and in various types of neuralgia. The older, and perhaps most often indicated form of treatment, is to obtain the anelectrotonic effect of the positive pole of the galvanic current. To obtain this the cathode is placed on the origin of the diseased nerve, the anode on the seat of pain, and the current gradually raised to its maximum, which should not be very strong, six to ten milliamperes; after the current has continued for two or three minutes it is gradually decreased, always being careful to avoid any sudden interruption of the current flow. Painful points along the nerve should be sought for and treated with the anode in the same manner. In most cases of simple neuralgia this treatment will be very successful, but there are cases which do better under the influence of the cathode, or when both poles are used alternately on the painful points, thus increasing the nutritive effect; in other cases the interrupted galvanic current is more successful.

The faradic current should not be discarded in the treatment of neuralgia, for it will often bring relief when the galvanic fails. Just what the difference is in the cases that require the one or the other form of treatment, we are unable to say. We believe, however, that the cases which require the anodic influence of the galvanic current are those of simple hyperæsthesia, due, perhaps, to some slight molecular change in the nerve; while those requiring the irritating effect of either the cathode or the faradic current are caused by a more deep seated nutritive disturbance.

Rockwell has given an indication for selecting the current to be used. If pressure on the painful points aggravates the pain, the galvanic current is indicated; if not, the faradic should be used; in our experience this indication has proved

very unreliable. The Duchenne method for treating neuralgia is first to dry and powder the part so as to increase the resistance of the skin, then applying the wire brush attached to the long, fine wire coil. Here the current is expanded upon the sensory nerve filaments.

Static electricity is gaining ground rapidly in the treatment of neuralgia. The static induced taken from the smallest sized Leyden jar is certainly very soothing, more so than any other form of application; but where extreme sensitiveness does not exist the static spray given faithfully three or four times a week, will be of great benefit in chronic neuralgia.

The high frequency current given by means of the glass vacuum electrode directly on the skin is a potent remedy for any superficial neuralgia. We have recently cured with a few treatments cases of supraorbital neuralgia that were of long standing. It is, however, of little, if, indeed, of any use in deep seated neuralgia.

We have tried the galvano-puncture, which was formerly highly recommended, in five cases. In one case, the nerve was very sensitive and the treatment very painful, perhaps owing to a slight inflammation the symptoms were aggravated. In two other cases where the treatment was not so painful, no effect was produced. Two cases where the treatment was not at all painful, were slightly relieved. The current was applied in the following manner: The anode, by means of a large electrode, was placed over some portion of the nerve above the point of the puncture. The cathode was attached to a fine needle, such as is used for removing hairs, and this was insulated with shellac to within a few millimetres of the point. This was introduced at several points along the nerve, and a weak current from three to five milliamperes passed for about one minute to each puncture.

Jones reports the complete cure of a most obstinate case of neuralgia by the use of sinusoidal baths for two weeks.

It has been found that in neuralgia certain parts or points of the affected nerves are exquisitely sensitive to pressure. A successful method of treating some obstinate forms of neu-

ralgia is to select these points as the best sites for the application of the electric current and apply the anode over them; the cathode is applied at some point above, preferably at the point of exit of the nerve from the cranium or spine. The current should be gradually increased and gradually decreased so as to get the full anelectrotonic effect.

Sperling has studied the subject very thoroughly from this standpoint and has given a table by which we can find these points or, at least, may look for them; from that table the following is taken.

Neuralgia of the Trigeminus Nerve. Painful Points on Pressure.—In the sphere of the ophthalmic division:

(1) Supraorbital point at the supraorbital foramen or along the course of the supraorbital nerve.

(2) Trochlear point: at the inner canthus of the eye.

(3) Parietal point, near the parietal eminence.

In the sphere of the superior maxillary division:

(1) An infraorbital point at the exit of the infraorbital nerve.

(2) A malar point at the zygoma.

(3) An alveolar point at the surface of the teeth in the superior maxillary bone.

In the sphere of the inferior maxillary division:

(1) A temporal point anterior to the ear.

(2) An alveolar point along the border of the teeth of the lower jaw.

(3) A mental point at the mental foramen.

In Intercostal Neuralgias.—Three pressure points are found in the intercostal spaces:

(1) Near the spinal column, at the exit of the nerves from the intervertebral foramina.

(2) Midway between the sternum and the spinal column.

(3) Adjoining the sternum.

Brachial Neuralgia.—In this affection, painful points will be found at the cervical vertebræ and some points along the brachial plexus.

In treating neuralgia, relief will follow for a certain length

of time after the first application and then the pain will return, at which time another application may be given ; if the treatment is to be successful, the period of relief following each application will be longer than the previous one. In calculating the probable effect of electricity in neuralgia, one thing should be taken into consideration, and that is the depth of the affected nerve. When a person is very fleshy, or the nerve is deep seated, electricity will not be as beneficial as when the nerve is superficial, for the current will be distributed in the overlying tissue and comparatively little of it will reach the affected nerve.

Sciatica.—While sciatica may be purely neuralgic, it may also be inflammatory, and it is sometimes difficult to tell when one or the other condition is present.

The static induced current is excellent to remove excessive sensitiveness and soreness in nerve tissue when there is but slight, if any inflammation, or after the acute inflammation has subsided. (See neuritis.) It is, however, practically debarred in many of these cases on account of its non-portability. We must, therefore, rely upon the fine coil faradic current or the galvanic, preferably the latter. The large negative electrode should be placed over the origin of the nerve, and stabile currents given with the positive on the sensitive points. A current of from five to ten milliamperes should be given on each point for from three to five minutes in a way to obtain the anelectrotonic action of the anode. It will be found that this will relieve the excessive acuteness of the pain, so that the patient can get out and come to the office, when static electricity should be used.

Steavenson had good results by a method which reversed the position of the poles. He placed the anode over the abdomen or lumbar region and gave labile applications along the course of the nerve with the cathode.

In nine very severe cases of sciatica which we have treated with static electricity, eight of the nine were perfectly cured, and, in our opinion, the ninth could have been cured had there been more time given to the treatment. With two ex-

ceptions, these cases were of over three months' standing, one being of eighteen months' duration, and all of the severest type. These cases had gone through various courses of medical treatment, from the legitimate rheumatic specialist to the clairvoyant. Furthermore, not one of these cases, to our knowledge, and we are sure we should have known it in some at least had it occurred, has had a relapse. Limbs which were shrunken filled out to the normal size and those which were so weak that they resembled paralysis, regained their normal strength.

The method of treatment is to begin with a light static breeze,—unless the extreme sensitiveness before mentioned exists, when a few applications of static induced may first be given,—and gradually increase in severity until a strong spray is given. It is seldom necessary to use the spark, but if a case should after being nearly cured, have a few pains hanging on with great persistency, the spark may be resorted to. There is probably no condition in which the electric bath has been more successful than in sciatica. Vergnes painted the course of the nerve with iodine to reduce the resistance and carried lithia into the part by means of cataphoric action of the current. The faradic bath has had good effect in sciatica and Jones specially recommends the sinusoidal bath. In very old chronic cases where there has been a deep seated inflammation resulting in adhesion, galvanism should be applied along the course of the nerve; this may be given in conjunction with static electricity.

Muscular Rheumatism.—This disease while not belonging strictly to the classification of the diseases treated in this place, may be properly considered at this time.

In muscular rheumatism we undoubtedly have the greatest field for electrical treatment. Here we have distinct indications between galvanism and static electricity. If there is great soreness and sensitiveness to the touch or pressure, galvanism or faradism, preferably the former, is indicated, but, on the other hand, if there is no such soreness and sensitiveness, as is usually the case, static electricity is indicated and

will, we believe, be successful in at least ninety per cent. of the cases. The strong breeze or spray given for from fifteen to twenty minutes will be sufficient except that in chronic cases,—such as are generally found in the deltoid muscles, and are due to neuritis of the circumflex nerve,—the spark will be required.

In acute muscular spasms, such as are found in an acute attack of lumbago, or spasm of the intercostal muscles, galvanization applied stabile, with the anode on the spasmodic muscles, is preferable to all other forms of treatment, but as soon as the spasms disappear, labile applications to the affected muscle with the cathode should be made. The nutrition of a muscle affected with rheumatism is always low and the greater power of the cathode in increasing nutrition is well known. If the static machine is not at hand, vigorous application may be made after this method in chronic cases with assurance of success. However, we believe the static spray will prove successful more speedily than the galvanic application. The galvano-faradic is very highly recommended by some and deserves all the praise it has received. The catalytic action of the galvanic current is here obtained and the stimulation of the contractions produced by the faradic current is well known as a muscle builder. This treatment is best indicated in the very chronic cases, when there is some atrophy and a quantitative decrease in the reactions.

In some cases muscular scar-tissue must be treated; the use of stabile galvanic currents acts advantageously here as well as in scars of the skin, producing softening of the tissue and amelioration of the pain.

In connection with muscular rheumatism may be mentioned dystrophia musculorum progressiv (Erb) which may be treated with central galvanization combined with local treatment. Static stimulation may also be employed.

Teno-Synovitis, a disease of the tendon-sheaths may also be noted in this connection. The treatment consists of labile galvanization with occasional faradic cutaneous irritation or with stabile galvanization.

In the treatment of muscular rheumatism, Larat gives preference to the electric bath with sinusoidal currents over all others, claiming marked success even in the most inveterate cases. The baths are given at 36° C and of short duration (6–8 minutes). Where the bath can not be employed, he states that the static spray, the faradic brush, or the high frequency sparks, may be substituted.

Multiple Neuritis.—If this disease is of an epidemic nature and due to a toxic condition, the first indication for treatment is to remove its cause. This will tend to establish a more or less complete regeneration of the nerves, and when aided by electrical treatment recovery will generally take place quite rapidly. In the non-epidemic variety electricity will generally cure it, requiring anywhere from two weeks to a year. The prognosis, however, is generally good under good surroundings. If a case be examined early, no perceptible changes in the reaction are noticed, but gradually as the disease advances, reaction of degeneration takes place in all the nerves that are affected. The completeness of the reaction of degeneration denotes the amount of degenerative atrophy of the nerve. If reaction of degeneration has been gradually developing and suddenly becomes stationary, it is a good omen, and the chances are that in a few weeks at most, reaction of degeneration will begin to gradually disappear. The electrical treatment will complete a cure rapidly in those cases where reactions have not changed to the point, that faradic irritability is lost, and in these cases the faradic current, is preferable. When faradic irritability is lost galvanism may be used. When treating a case with the faradic current the high tension coil should be employed, and the amount of current passed must be small, not enough to produce contraction. The application of one pole should be made to the affected nerve, while the other is over that section of the spine which gives rise to the nerve.

In using the galvanic current treatment should be given labile, with the anode over the affected nerves and the muscles affected by them, and the cathode resting over that section of

the spine which gives rise to them. The special point in the treatment of this disease is to use a very weak current, five to ten milliamperes, but continued a very long time, at least twenty-five or thirty minutes. This treatment has, in our hands, proved far more successful than giving stronger currents for a shorter space of time. Static electricity has been highly recommended by some, but we have never had the beneficial results with it that we have had with galvanism and faradism. If it is to be employed, the static spray for some time, twenty to twenty-five minutes, gives the best results. Static electricity is most beneficial in those cases where sensory changes are present. Cohn recommends "labile combined galvano-faradic treatment of the affected parts. In cases where irritability has ceased, all electro-therapeutic measures are useless." When secondary contractures supervene, massage is frequently of much service.

Chronic Lead Poisoning.—So far as a general lead poisoning is concerned, it has been proved that much benefit may be derived from the cataphoric action of the galvanic current. The electric bath is very highly recommended for this condition. The patient is placed in the bath, to which is attached the cathode, the anode, a very large one, being placed either over the chest or back, above the water. For the paralysis following lead poisoning, electricity has been found most useful. The reactions of this disease largely resemble multiple neuritis. If the disease is at all advanced, reaction of degeneration is present; it is not present, however, in the early stages, but comes on by gradual development. It has been claimed that after a treatment of this kind deposits of lead have been found covering the electrodes connected with the cathode.

Dr. Edwin De Baun reported in 1885 two cases of lead paralysis in type setters of both flexors and extensors of the right forearm. In one the reaction of degeneration was present and was greatly benefited by labile applications of one pole of the galvanic current over the affected muscles, the other pole resting over the brachial plexus. Very weak currents varying from two to ten cells were given twice a day

with sittings from fifteen to twenty minutes each. The poles were used alternately. The other case was very similar, so far as the distribution of the disease was concerned, but the reactions of degeneration were not present; at least faradic irritability was not lost. Galvanism was given the same as in the first case but without success, when faradism was tried in a similar manner with very great improvement of the patient.

We have treated eleven cases of lead paralysis of the forearm and hand. Three of these have been markedly successful, six have been moderately successful and two total failures. The two in which there was no result were chronic alcoholics of an exaggerated type. This disease like multiple neuritis should be treated with a mild galvanic or faradic current, continued for at least fifteen to twenty-five minutes, the indications for the particular current used depending upon the presence or absence of the reaction of degeneration. Static electricity has been of use in this disease, but is inferior to galvanism.

Arsenical, Mercurial and Other Forms of Chronic Poisoning.—The cataphoric treatment of various forms of chronic metallic poisoning through the medium of the electric bath has proved successful. The case reported by M. Poey before the French Academy in 1855, of an electroplater who suffered from an obstinate ulcer on the hand, thought to have been caused by constantly dipping the hand into a solution of nitrate and cyanide of silver in his routine work, is of great interest. On one occasion on immersing his hand in the solution before the object to be plated had been put in, the cathode wire became covered with a metallic film. The conclusion was that the metal came from the man's hand and the operation was repeated in order to remove all metallic substances, when the ulcer healed. Many cases from not the most trustworthy sources have been reported of mercury having been removed from the body by cataphorisis. This subject, however, will need to have more light thrown on it before it can be said to have reached a practical stage.

Alcoholic Neuritis.—In the charity hospitals of large cities a form of neuritis in chronic alcoholics is met with which exhibits a progressive character, so far as changes in reaction are concerned. In the early stages of this disease no changes are noticed, but in the later stages quantitative changes and finally reactions of degeneration are frequently present. There is no doubt that, by a discontinuance of the use of alcohol, together with a full diet, this disease has a tendency to recovery, but that electricity will be of great benefit in hastening this recovery is proved by the rapid improvement which takes place after the first or second treatment. The only contraindication to electrical treatment is severe and persistent pain. If there be no reactions of degeneration present, the faradic current may be used, but even in this case the galvanic is better and when reactions of degeneration are present, the galvanic should always be used. The treatment is the same as that given in multiple neuritis, to which the reader is referred. Jones speaks highly of the sinusoidal current for this disease, especially when given through the medium of the bath. We have never had any experience with the sinusoidal current but can vouch for the great benefits to be derived from the use of galvanism.

Exophthalmic Goitre—Graves' Disease.—This disease has been more or less successfully treated by electricity. Various methods have been tried, but all agree that the greatest benefit is derived from galvanizing the sympathetic nerves and the upper part of the spine. Erb passed a constant current through the eyes and through the temples, but he is doubtful of its efficacy. Others have tried galvanizing the spine, while still others have passed strong galvanic currents through the head, although these have not apparently secured any material benefits. General faradization or the static spray may be given for their tonic effects. The cases in which treatment is most likely to be successful are those of recent origin, with a fairly good constitution and no organic lesion of the heart. When the latter is present together with a strumous constitution but little may be accomplished.

We have treated nine cases. Four were successful so far as

known, but all with one exception passed from observation within a year. Two were slightly benefited through the reduction of the frequency of pulse rate, by diminishing the thyroid and improving the general condition; and in two no material results were obtained.

There is a diminished resistance of the body in this disease, in some individuals but slight and in others it is very noticeable. Cardew claims this is due to the great tendency to perspiration and consequent lessening of the resistance of the skin.

The method of applying the galvanic current to the cervical sympathetics is to place an electrode connected with the cathode over the cilio-spinal centre above the seventh cervical vertebra. The anode should be placed over the auriculo-maxillary fossa, and after holding it stabile for a minute or two, labile applications may be made all along the inner edge of the sterno-mastoid muscle, using a current of medium strength. The next step is to remove the anode to the position occupied by the cathode and place the cathode over the solar plexus; pass a very strong current for one or two minutes. This is Beard and Rockwell's method, and is the most successful we have ever used. The same authorities recommend, when this treatment is not successful, rapidly increasing and decreasing the current strength, by means of a rheostat, during the application. The puncture has also been recommended, and with good results; but, the method used does not differ from that given for goitre, to which the reader is referred.

Sperling recommends general faradization which should mostly be confined to the trunk, central galvanization with special reference to the neck and the static head spray, of one minute's duration. This combined treatment has been found very efficacious.

Cohn claims the greatest success in the treatment of this disease from galvanization of the thyroid gland. Current strength of $\frac{1}{2}$–$1\frac{1}{2}$ ma. is employed, the poles being changed to and fro, great care being taken not to change the poles during closure. The electrodes are placed on both sides of

the thyroid gland and treatment should consume 5–10 minutes.

Myxœdema.—It has been claimed that electricity has been beneficial in myxœdema. There is no systematic method of treatment of this disease. We have never had the opportunity to treat a case of myxœdema, but believe that the only beneficial effect that could be derived from the electric current would be in its tonic effect from general faradization, or from the general static breeze. However, the catalytic action of the galvanic current may be of use in the swollen parts, and this would be best obtained by passing the current directly through the parts affected. Taking the pathology of the disease into consideration it would seem that its efficacy would be very small. Central galvanization might be used to advantage. It is, however, entirely speculative.

Hysteria.—There is probably no disease in the treatment of which electricity has been more extolled, and at the same time has been more disappointing than hysteria. We believe much of the disappointment has been largely due to the fact that it has been used for its purely psychic effects, and that there has not been taken into consideration the depressed state of the nervous system, in which electricity has a great power of stimulating nutrition.

There are cases that come under the head of hysteria in which the suggestive power of electricity is all-sufficient, but there are others in which the suggestive power is good for nothing. Often there appears a case of paralysis which has been real, due perhaps to a neuritis, which has healed but has left the paralysis, the patient not being aware of the true condition; a few contractions of the muscles with the faradic current stimulates confidence and cures the case. There are often cases of neuralgia accompanying some real disease, in which a single application will relieve. Electricity may, in fact, be used for its suggestive power with great success in many cases. A very severe shock to the nervous system will produce the desired effect in some. A great display of fireworks, such as can be produced by the static battery without shock to the patient, will oftentimes have the desired effect. Hysterical asthma is

often cured by passing a current through the larynx from side to side. At other times a shock which produces a sharp pain will cause the patient to scream, when of course the aphonia is no more. But in a large proportion of cases the suggestive power of electricity will be of no avail. It is desirable here to obtain the catalytic and nutritive effects upon the brain and spinal cord, as well as upon the disabled part or member.

The best method of treating the brain and spinal cord is to pass a galvanic current longitudinally and transversely through the head, then lengthwise and transversely through the spinal cord. After this the treatment should be given according to the condition present. For motor disturbances, the faradic current is generally preferable, as it produces strong muscular contractions, and thereby has a greater demonstrative power upon the patient's mind, but for sensory changes the static is preferable. The sparks or a vigorous static spray producing the stinging sensation, has a similar effect upon the sensory nerves that the faradic current has upon the motor. However, galvanism is not to be entirely ignored as it will sometimes produce results when the static and faradic fail. It would be impossible in a work limited in scope as this is, to give all the different forms of disease which hysteria is apt to simulate. Take for instance sensory disturbance. This may occur in any part of the body. It may take on the form of hyperæsthesia, when a soothing current should be applied. It more generally, however, takes on the form of anæsthesia which would better be treated with a strong static spark or the faradic brush. If a strong faradic current is not felt in a case of anæsthesia, it is not hysterical, but is due to some more serious condition for with hysterical anæsthesia the faradic current produces as much or nearly as much pain as it does when no anæsthesia exists. There may be a loss of muscular sense which might be treated in the same way. Neuralgia which comes under this head is generally more quickly relieved with the galvanic current, although the faradic will sometimes produce better results. It does not seem to matter which pole of the galvanic battery is used over the neuralgic points

and this fact may be used in diagnosis for if it be a true neuralgia the anode will relieve much quicker than the cathode. Clonic spasms of hysterical origin may be treated the same as clonic spasms that are not hysterical. The positive pole is placed upon the spasmodic muscle and the current gradually raised and as gradually decreased. We have also various forms of spasms of the viscera that are hysterical as well as hysterical paralysis of the viscera. Treatment of these need not differ from those of real paralysis, except perhaps that we use a more vigorous form of treatment in our efforts to affect the patient's mind. In that form of general convulsions known as hystero-epilepsy, the convulsion may be cut short by the application of the current during the attack. Various methods for its application have been advocated. Some claim that a faradic current along the spine is correct. Charcot advised an interrupted galvanic shock through the head while still others have given strong galvanic interruptions through the body, using as high as thirty or forty milliamperes. It does not seem to matter according to our experience what current is used or where it is applied. One current is as successful as the other. Charcot states that after static electrolization pressure on the hystero-genetic fails to produce an attack as it does before the electrolization.

The object sought in treating these cases should not be so much to cut short the attack at the time as to thoroughly build up the patient by galvanism through the head and along the spine, and by general faradization or the static breeze between the attacks, thus preventing their recurrence. The treatments should be given daily. Hysterical contractures are successfully treated by electricity. Some authors, principally Ranney, have claimed, that the strong static spark is effective in relieving contractures. We have not found this true when actual contractures existed, but have found it quite successful in hysterical contractures. The vaso-motor disturbance such as elevation of temperature, salivation, and polyuria should be relieved by the same general treatment.

Through this entire book it has been the aim to give electro-

therapeutics only, but failure will be the reward of everyone who does not go beyond the electrical treatment in hysteria. There is no disease in existence in which the personality of the physician has so much influence toward the cure or failure as in hysteria. The physician who cannot control his patient by the quiet, subtle power of suggestion as he comes in contact with her, had better not treat hysteria. One patient must be treated with the kindest of consideration and all things be explained to her. Another one must be handled sternly and know nothing. With one the physician must agree with all she says to gain her confidence, and with another the physician must protest that she is not suffering at all. The temperament and character of each patient must be carefully studied, and the physician must feel his way carefully along until he grasps the entire condition; then he is prepared to go ahead and utilize electricity, not only as a suggestive but as a tissue builder and as a strong tonic.

Sperling claims that the treatment of hysteria by electricity will not prove successful unless combined with pyschical treatment, which modern writers term "suggestion." If electrical treatment is thus used as a cloak and acts pyschologically on the patient, improvement will usually be noted; hysteria treated on other bases will often be full of disappointment. He does not, however, wish to imply that it is immaterial how and where the electrodes are to be applied in hysterical patients who suffer from some distinct complaint such as neuralgia. On the contrary, it is a fact of daily occurrence, that, the more precise and mild the application, the better the results. As a rule, the treatment of hysteria must be symptomatic depending on the removal of an hemi-anesthesia, paralysis or contracture, neuralgic localized pains, ovaralgia, asthma, globus hystericus, etc. The usual methods are employed, special attention being given to such procedures which will strongly impress the patient. The faradic brush and the static spray or spark are preferable, while galvanism is relegated to the rear. The nutrition and mental and physical occupation must be looked after and carefully regulated.

Neurasthenia—Nervous Prostration.—Neurasthenia is generally divided into cerebral and spinal. However, one cannot exist wholly without the other, and so far as the electrical treatment is concerned the more general it is given the better. Not only is cerebral and spinal neurasthenia included under this general head, but also that form of neurasthenia following accidents known as traumatic neurasthenia, sometimes called railroad spine or railroad brain. Spinal irritation is also included under this caption as we believe it to be only a form of neurasthenia although it is thought by many to be due to anæmia of the posterior columns of the spine. Insomnia and other allied conditions are but symptoms of neurasthenia and are also included here. There may be a local neurasthenia of the eyes, digestive and other organs, but in order to cure the patient it is necessary to give a general treatment as all forms of the disease depend to a greater or less degree upon a general depression of the nervous system.

The success of electricity depends largely upon the constistution of the patient and the cause of the neurasthenia. Many patients are born neurasthenic ; they live miserable lives from constitutions for which they are not to blame. Others have been born with such a neurotic temperament, that the least strain upon the nervous system brings on neurasthenia. Others still have destroyed their nervous system by excesses and intemperance so that they have no resistance. For cases of this kind it is difficult to do much, and about the best results that can be expected are palliative. However, much suffering may be prevented by a proper electrical treatment in many of these conditions and the patient may be made far more comfortable and restored to the degree that he is relieved from suffering, which in itself relieves the neurasthenia, as the symptoms of neurasthenia help to prolong it.

Cases which are most benefited are those which are purely functional, such as are traceable to spinal anæmia, excitement, overstrain at work and anxiety. The prognosis is particularly good in this class of cases if the patient has by nature been

endowed with a sound nervous system and that has never been abused by bad habits.

All forms of electricity are of use in neurasthenia, but when using galvanism the treatment should be given cautiously for there are many cases of neurasthenia where galvanism aggravates the case very much. This is particularly true of spinal irritation. It is not uncommon for these cases to have a sinking spell, from one to five hours, after galvanism has been given to the spine. The cases in which galvanism seems to be best indicated are those of a general neurasthenic type where there is a lack of nutrition to the nerve centers, and where the mental symptoms, so characteristic of this disease, are present together with insomnia. In these cases galvanism should be given so as to bring its greatest action upon the cerebro-spinal centers. Longitudinal and transverse currents may be given through the brain, both ascending and descending along the spine as well as transversely. Central galvanization will be found most excellent. When this treatment is given it should not be continued for more than eight or ten minutes, and the current strength varying from fifteen to twenty milliamperes along and through the spine. According to our experience the greatest benefits will be derived from general faradization and the static breeze. The faradic current is used in those weakened conditions were the patient is constantly tired, too weak to exert himself mentally or physically, where the least mental exertion tires him so that he does not recover for days, and where physical exertion does the same. In these conditions general faradization will be found most effective. After the patient has been gone over a gentle current should be allowed to pass through the body for quite a long time ; one electrode may be placed on the feet, and the other on the spine or the foot electrode may be removed to the abdomen. The point is to get a large portion of the body in the circuit and allow a gentle current to pass for fifteen or twenty minutes. Static electricity seems to be well indicated in spinal irritation and traumatic neurasthenia. In spinal irritation the sparks should be given, and it is remarkable how

these very sensitive spines will bear with impunity the strong static sparks. At the same treatment the spray should be given over the entire body.

There is probably no condition where the tonic effect of electricity is so pronounced as in traumatic neurasthenia. It should be given in the form of a vigorous spray for fifteen to twenty minutes, concentrating it to a degree on the painful points and imaginary spinal lesions. There is no disease where it is so essential that the patient should have at least fifteen to twenty minutes' rest after the treatment as in neurasthenia, and even an hour is far better. The electric bath has been recommended highly for neurasthenia, but we have had no experience with it.

When we come to special forms of neurasthenia, it is best to concentrate the current upon the local organs affected. Insomnia is best treated by passing a longitudinal galvanic current through the head as recommended for cerebral congestion, and also through the spine, combined perhaps with static electricity or faradism. If there is a sensitive condition of the stomach and other parts, the electric current should be given ascending according to the rules laid down for those conditions. So varied are the complications that may arise in neurasthenia that they cannot all be given in detail here, but only good judgment, with an understanding of the general action of the electrical current on the body, is required to prescribe a treatment. The general diet and nourishment of the body is all important as well as the general management of the case and should be carefully taken into consideration.

DISEASES OF THE PERIPHERAL NERVES.—All those diseases of the peripheral nerves which are of a general character, have been treated of in the preceding section. Only inflammatory diseases and troubles arising from injuries have been reserved for this section.

Neuritis.—It is necessary to divide neuritis into the acute and the sub-acute or chronic stages. The only object of the electrical treatment in the acute stage is to relieve the pain and thereby save the patient from narcotics. This is best accom-

plished by placing the positive pole over that portion of the spine which gives rise to the diseased nerve, and give labile applications over the seat of inflammation. This has been found to be more successsful than the anelectrotonic effect of the current. It is a question, however, whether the current is of benefit in the acute inflammatory stage. That much temporary relief is afforded there is no doubt, but as surely more or less irritation which may prolong the attack, is produced. After the inflammation has subsided to a large degree and paralysis is left, electricity is the remedy par excellence. Of course, the reactions are very characteristic, and give a clue to the diagnosis as well as the prognosis. If the reaction of degeneration comes on in the early stage, and the seat of the inflammation is not within a bony canal, it is a pretty sure indication that the inflammation is deep seated within the nerve. If, however, the reaction of degeneration does not take place, or takes place slowly, and is only slightly manifest, the sheath is likely to be the seat of inflammation. This, however, cannot be taken as a guide, when the inflamed nerve is within a bony canal or foramen, for a slight inflammation will produce effusions and cause paralysis from pressure and the reaction of degeneration, as the bony covering will not expand. It is for this reason that such slight inflammations produce paralysis of the seventh nerve, Bell's paralysis.

The object to attain in the electrical treatment of these cases is, first, to absorb whatever effusion or deposit there may be, and to try to force a current through the nerve, thereby increasing its conductivity, and, second, to stimulate the muscles into exercise by the interrupted galvanic current. Just when the current should be given is a very important question. Slight stabile or even labile applications may be given very early, after the subsidence of the acute symptoms, but the interrupted current should not be given, until most of the pain and soreness has disappeared. With an ordinary neuritis, the positive pole should be placed above the sèat of lesion and the negative below, giving a descending current through the inflamed area. After this a current may be given

transversely through the seat of inflammation in order to absorb any effusion or deposit. Then place the positive electrode over the origin of the nerve, and with the cathode give an interrupted current to all the motor points, causing vigorous contractions at each one.

Neuritis may occur in any part of the body and may require some special form of treatment according to the location, but these are the general rules which should govern the application, no matter where the seat of the disease may be.

Bell's and Other Forms of Paralysis.—Bell's paralysis, probably the most common form of motor paralysis, is very successfully treated with electricity. The method of treatment is simple; the anode is placed directly behind or just below the ear, while the cathode is first given labile over the face, and then each motor point is carefully gone over with a small nerve electrode and several vigorous contractions produced. The same may be given to the brachial plexus, median nerve, ulnar nerve, or in fact any nerve of the body. The length of time required in curing these cases varies. Where no reaction of degeneration is present, the patient will recover in from two to four weeks. If R. D. is slightly present at the end of the second week, it will require from five to eight weeks to effect a cure, and when pronounced early in the disease, showing a deep seated inflammation, several months will pass before the recovery is complete; if there is destruction of the nerve fibers, of course recovery will never be complete. It is important to begin treatment as early as possible in these cases, for there is always more or less degenerative atrophy of the muscles which is progressive, and it is to prevent this progressive atrophy that treatment should be given promptly.

Another point should be carefully borne in mind, and that is, whenever reaction of degeneration is present, the faradic current will do far more harm than good. This statement we make after much experience and careful consideration of the subject, and with due respect to some prominent authors who disagree with us. Here we must always rely solely upon the galvanic. As each muscle of the body always has an antago-

nistic muscle working in opposition to it, the great danger with paralysis of a muscle or group of muscles is that it produces deformity, that its strong antagonistic fellow works against it, drawing the member out of its natural position, and by its greater strength preventing the weaker, if not entirely paralyzed, from flexing or extending the limb. When reaction of degeneration is present, the faradic current does not stimulate those muscles, but if applied to them in any considerable strength it produces contractions of the antagonistic muscles by the leakage of the current to them, thereby developing the antagonistic or strong muscles at the expense of the weak ones, and increasing the deformity.

Static electricity should by no means be ignored in the treatment of neuritis. It is most beneficial when given in a light positive breeze to relieve the soreness and pain in a declining attack, but is of not much use to relieve the motor paralysis which follows. We have recently relieved a slight neuritis of the genito-crural nerve with the static wave current. In anæsthesia following a neuritis of a sensory nerve, static electricity is of great value. Here the vigorous static breeze and later on the static spark, is of the greatest use and will surpass any other form of application known to us.

Traumatism of the Nerves.—This subject has been very thoroughly treated in electro-diagnosis. When reaction of degeneration is complete, owing to the severance of a nerve, and the nerve has been united, it will depend largely upon the completeness of union how soon the reactions begin to return to their normal condition.

In two cases which were recently examined one month after the operation, with the first there was no change whatever; three months after the operation, galvano-muscular contractions began to improve; but it was six months before galvano-nerve reactions were apparent in the slightest degree. The patient never completely recovered.

In the other case, one week after the operation, the reactions began returning to a normal condition, and the patient recovered rapidly and quite completely. The difference in

these cases was simply due to the completeness of the uniting of the nerve, one being united perfectly or nearly so and the other but very imperfectly. The treatment, after a nerve has united, does not materially differ from that of neuritis. A current should first be passed down the nerve to increase its conductivity. If deposits have been thrown out, as they generally are in the healing process, the current should be passed through the seat of the lesion, then with applications to the motor points vigorous contractions of all the muscles should be produced. Applications daily or every other day should be given, using always the galvanic current as in neuritis. The rapidity of the recovery will depend upon the severity of the lesion, upon the neurotic tendency of the patient and the length of time that has elapsed between the injury and the repairing of the nerve, for all these conditions depend upon the amount of degenerative atrophy that has taken place.

In cases where the lesion is localized over a small area (such as in radial paralysis from pressure during sleep) stabile galvanic treatment is employed, or that may be interposed during labile treatments.

The labile application is especially applicable for the symptoms of paralysis and for atrophy of the muscles; the stabile application for the removal of pain; the former is frequently required to remove æsthesias and paræsthesias which remain in many cases of neuritis after the main symptoms have been removed. In these cases, the faradic brush or the static spray or spark should be employed for combating these vestiges of the disease.

This method of treatment applies, in general, to all cases of neuritis, whether due to traumatism or rheumatism, to surrounding inflammations, to mercury, alcohol, lead or arsenic poisoning or to infectious diseases (diphtheria, multiple neuritis).

SECTION THREE.

Gynæcology and Obstetrics.

Electro-gynæcology is a subject that has been fraught with much discussion, some of which has not been entirely free from vituperation. Undoubtedly, many claims have been put forward in this branch of therapeutics that were not based upon careful observation; on the other hand, the surgeon has often not been willing to concede that which abundant experience had proved.

Electricity in gynæcology occupies a comparatively small field, but in that field it has claims second to no other therapeutic method of procedure. Indications and contraindications are well known, and the mode of action is well established. In this section those diseases in which we have found by experience that electricity is useful as a therapeutic agent, are discussed. It will be noticed that diseases of the Fallopian tubes, barring simple and catarrhal inflammation, are not mentioned here. We believe, after no small amount of observation, that the claims put forward for the electrical treatment of other diseases of these tubes are not only largely fanciful, but may, when put into practice, often prove pernicious.

Amenorrhœa.—In order to thoroughly comprehend the treatment of amenorrhœa, it is necessary to divide it into three classes:

First: Amenorrhœa due to a lack of development of the genital organs. We are well aware that the amenorrhœa is here only a symptom of the condition, but as it is the symptom

which calls attention to the condition, we have concluded to give it at this place.

Second: Amenorrhœa due to general conditions of the body such as anæmia, tuberculosis and Bright's disease.

Third: Amenorrhœa due to outside influences, such as cold, fright, etc.

It must be obvious to anyone, that if there is a total lack of development of the genital organs nothing can be done to improve the condition, but in those cases where there is considerable development, but not quite enough to produce the normal requirements necessary to the completing of a woman's whole function, much may be done. In cases that are to be benefited, it will be found, that the external development of the woman is more or less complete. The figure will have a womanly outline. In a case which we examined for this condition some time ago—that of a young lady twenty-one years of age—her whole outline was more the figure of a man, and an examination revealed that the vagina ended in a sack, while not the least rudiments of a uterus were to be found.

The outward manifestations and signs of development of the external organs will also be present, such as a slight development of the mammary glands and a growth of hair on the pubes. Every month there will be periodic sensations, such as a bearing down in the pelvic region, a feeling of weight, and perhaps aching in the hips and back, as if the flow was about to make its appearance but does not; or, perhaps it may appear very slightly, a few drops, just enough to stain the underclothing, and possibly give some relief. Bimanual manipulation will reveal a small uterus which is easily compressible. Vaginal examination brings to view a small pale cervix, and a uterine sound will probably demonstrate that the cavity is only from one to two inches in length. If the examination is made at the time the periodic menstrual symptoms are present, the uterus will be found to be slightly larger, and instead of being soft and compressible, will be hard and elastic, and the cervix congested instead of pale. This will be due to the congestion which the stimulus of the undeveloped organs

produces, but which lack sufficient energy to complete the normal function.

Such a case is generally amenable to treatment if the patient is under twenty years of age—the younger the better; but if the patient is thirty to thirty-five or forty years old, the prospect of a cure is very much diminished.

When we come to consider the second classification, it will appear evident to anyone, that if an amenorrhœa is due to anæmia, the proper thing is to cure the anæmia by building up the blood. No local treatments of electricity should be employed; for nature, by stopping the normal flow in anæmia, as well as in consumption, Bright's disease, or any other depleting disease, acts as a safety valve in preventing a still further drain on the impoverished blood. The general application, however, of electricity as general faradization, or a general static breeze, will be of benefit in connection with other remedies for the anæmia.

There are cases of amenorrhœa in young girls, perhaps in girls who have never menstruated, due to anæmia—particularly that form of anæmia, if it may be so called, known as chlorosis—in which, as the anæmia is improving, all the periodic symptoms, such as bearing down in the pelvic region, pain, weight in the hips, loss of appetite and sleep, that are described under lack of development, appear regularly but without any flow. Such cases will be very materially improved by local treatment. It need not be given when the symptoms first make their appearance, but if they continue with no sign of the flow, the local treatments should not be delayed.

When we come to consider the third classification, we must distinguish between the acute and chronic conditions. There is a class of cases of amenorrhœa—due to exposure to cold, to getting the feet wet during the menses, or just before the flow should appear, or perhaps, to some sudden fright or grief that has been the exciting cause. The patient will come to the general practitioner in a very excited state, with flushed features, full pulse, a temperature ranging near one hundred,

sleeplessness, loss of appetite and very marked irritability and apprehension. All that these cases generally need is good care, rest, a relief of their apprehensions by assurance on the part of the physician, and the appropriate remedies. But, unfortunately, some of these cases do not respond to this kind of treatment, and while all the nervous and febrile symptoms disappear, the amenorrhœa becomes chronic. We have known cases of this kind to continue for months. These are the kind that most frequently call for electrical treatment, and the treatment will generally be successful.

In the cases of young ladies where it is desirable to avoid internal treatment if possible, or when internal treatments are refused, and when the case belongs to the second or third classification and not to a lack of development, the external treatment should first be tried and may be all that is required ; but, if it should fail, prejudice should be overcome and the internal treatment resorted to.

The external application of electricity may be given with one medium-sized electrode, the negative being placed at the lower end of the spine so that it bends down slightly on the coccyx, the positive being placed at the back of the neck, and a current varying from 10 to 20 milliamperes given for about five minutes ; then the positive electrode should be removed from the back of the neck to just above the pubes, and the same strength of current given for five minutes more. The external application of the faradic current is of little use for amenorrhœa.

If one owns a static machine this will be found of great service, for it not only frees the patient from the necessity of exposing herself in the least, but the strong static spark produces as good results as any other application of electricity given externally.

One must, though, depend on the internal application of electricity in obstinate cases of amenorrhœa. This is given by introducing into the uterus, an electrode to which is attached the negative pole, the positive, a clay pad, being placed on the lumbar plexus. A current of from 30 to 50 milliamperes

may be given for from five to ten minutes. The faradic current is not so active in producing the menstrual flow as is the galvanic; but some claim that, when it is given in conjunction with the galvanic, it facilitates action. Paneck, however, claims wonderful success for the faradic current. He applies both poles inside the uterus by means of the bipolar uterine electrode and gives treatments ranging from five to fifteen minutes daily. He reports eighteen cases cured in from five to thirty-five days. It may happen that the galvanic current will produce some disagreeble sensations in the pelvis. In this case, it will be well to attach the cords to a faradic battery and give a light faradic current of tension for two or three minutes after the application of galvanism.

When the faradic current is given in conjunction with the galvanic, that is, attached in the same circuit, galvano-faradic, for the purpose of promoting stimulus, the medium coil should be used. The length of time required to produce a cure will, of course, vary with the cause and the chronic condition of the disease. In those cases in which the amenorrhœa is due to cold, fright, etc., and is of recent origin, good results may be expected in from one to three months; but when the cause is due to a lack of development or one of the deeper-seated causes, from three to six months may be required. The frequency of the treatments will be governed by the ability of the patient to bear them. It is best, as a rule, to give electrical treatments in gynæcological practice not oftener than three times a week, but if the case is very urgent, or if the patient is away from home and is anxious to get through with it, the treatments may be given oftener, provided they do not produce any unfavorable symptoms.

Dysmenorrhœa.—Only two forms of dysmenorrhœa will be considered in this connection, as most of the cases of dysmenorrhœa are due to some form of inflammation of the pelvic organs and will be treated under their respective classifications. The two forms considered here are the so-called obstructive dysmenorrhœa and membranous dysmenorrhœa.

Obstructive Dysmenorrhœa.—It is a question whether the obstruction in a case of dysmenorrhœa is the primary cause or whether it is secondary, the primary cause being an endometritis, in which the obstruction is due to the congestion and consequent thickening of the endometrium. Which ever it may be, there are many cases that are relieved by an enlargement of the internal os. Those who claim that the constriction at the internal os is secondary to an endometritis believe that it is not the removal of the obstruction to the flow which relieves the symptoms of the dysmenorrhœa, but the free drainage of the endometrium which is a consequence of an enlarged opening. There are various ways of dilating the internal os, such as the tent, and the forcible or gentle dilatation by means of various instruments of the surgeon's armamentarium. It

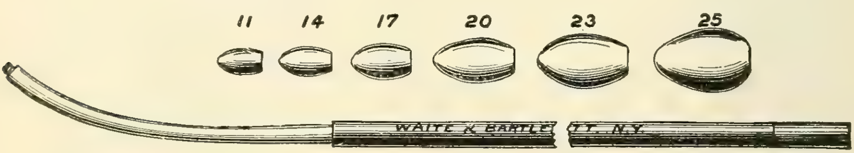


FIG. XIX. Bulb Electrodes for Treating Stricture of the Internal Os.

requires a longer time to effect the electrical dilatation; but it is less painful and is very much more lasting in its effects. There are cases, however, in which the patient is so sensitive, with a nervous system destroyed by the long period of suffering she has undergone, that she cannot bear the treatment, and the dilatation will have to be made under an anæsthetic. These, however, are rare exceptions.

The method of treatment is similar to that adopted in treating stricture of other canals, but it may be crowded faster than in stricture of the urethra, After the caliber of the constriction has been diagnosed, a bulb electrode one or two sizes larger is selected. This is, of course, attached to the negative pole, the positive being attached to a large sized electrode which is placed over the abdomen. The bulb of the electrode is pressed firmly against the contraction and a current of from ten to fifteen milliamperes is turned on. Steady pressure is

constantly made on the instrument to keep it in contact with the stricture until it passes through. It is then withdrawn in the same manner, and the current is turned off. If it has taken more than ten or twelve minutes for the instrument to go through, the same bulb should be used at the next treatment, which may be given three days after, but if it passed through easily in from five to ten minutes, a size larger may be used at the next treatment. It will not infrequently be found, that the pain will remain after the obstruction has been removed and yet there is no apparent endometritis or other discoverable cause to account for it. In this case, the application of galvanism to the interior of the uterus, using a large sized aluminum or platinum sound, which is attached to the positive pole, the negative in the form of a clay electrode being over the abdomen, with a current of from 50 to 75 ma. given twice a week, will relieve the patient entirely. This may perhaps, be explained by adopting Dr. Wylie's theory that dysmenorrhœa is due to a hypersensitive zone above the internal os and the anelectrotonic action of the positive pole removes it. Whether this be true or not, the treatment is very effective.

In dysmenorrhœa of a nervous or neurotic origin Larat employs the electric bath (with sinusoidal currents) with uniform success. When dysmenorrhœa is due to obstruction, the method as outlined above is found most serviceable. In obstructive dysmenorrhœa during the periods and just preceding the same, when the pains are severe, the sinusoidal current will be found palliative, being much superior to faradization. The technic for the electic bath is as follows: With water at 95° F. the electrodes of the sinusoidal apparatus are placed at the head and foot of the bath tub for fifteen minutes, the current being gradually increased until there is mild contraction of the superficial muscles of the body. Then for five minutes the electrode at the foot is moved to the hypogastric region, the other electrode being placed at the back of the patient. These baths should be given every other day, one month's treatment being sufficient to cure most cases of nervous origin.

Membranous Dysmenorrhœa.—In normal menstruation there is a degeneration and an exfoliation of the degenerated membrane with the flow, while in membranous dysmenorrhœa this membrane is exfoliated without properly undergoing degeneration.

It will generally be found necessary to first dilate the internal os as has been described under obstructive dysmenorrhœa, but the positive pole should be brought to bear on the interior of the body of the uterus. The hemorrhage which takes place in this disease at the time or immediately after the expulsion of the membrane should be considered in the treatment as much as should the pain before its expulsion, and as the positive pole is very hæmostatic in its effects, that is the one that should be chosen.

In order to effect a cure two things are essential: First, begin treatment as early as possible after the cessation of the menstrual flow,—it has even been recommended to begin treatment on the last day of menstruation—and, second, bring the action of the electrical current on the entire surface of the interior of the uterus.

Different methods have been used to accomplish this latter object. One is to use various sized electrodes made of carbon or aluminum. An electrode is selected that is of such a size that, when it is pressed into the uterine cavity it will come in contact with both anterior and posterior walls, so that, by a little manipulation, the entire surface of the membrane may be brought under its influence. The current must also be strong enough to produce chemical-galvano cauterization. The effort should always be made to reach one hundred milliamperes. If, however, that cannot be reached, the current should be continued longer in proportion. If this cannot be done, another method of treatment should be adopted; that is, use an instrument which has a small uninsulated point by means of which the current is concentrated on a small part of the mucous membrane. This instrument is so arranged that it can be moved when one spot has been sufficiently acted upon, to another, and, so on, until the entire surface of the mem-

brane is brought under its action. The membrane should be thoroughly cauterized in this way as soon after menstruation as possible. If this can be done with one treatment, no more need be given until after the next menstrual period; if it cannot be accomplished in one treatment, more should follow. In particularly sensitive women this treatment may be given under an anæsthetic, when as strong a current as is necessary may be used, thus thoroughly cauterizing the membrane, and only a few treatments, following as many menstrual periods, will be required.

Endometritis.—Acute endometritis is rare and is usually slight so far as constitutional or local symptoms are concerned. But in chronic endometritis we have one of the most common forms of disease to which woman is subject.

Cervical Endometritis.—Cervical endometritis, commonly called uterine catarrh, as its principal symptom is a profuse catarrhal discharge from the external os, is due to a chronic congestion of the cervical endometrium, which causes an exfoliation of the epithelium faster than its formation, thus leaving the surface covered with young epithelium, and this gives rise to a very reddish color.

If the disease is of long standing there may be an increase of the connective tissues, together with an enlargement of the blood vessels, making the membrane too large for the surface. This causes it to be thrown up into wrinkles which, gives it the appearance of a granulated surface whence it is sometimes called granulation of the cervix. In some cases, particularly those which have had caustics applied, the mouths of the Nabothian glands become closed, thus damming back the secretion which forms cyst-like bodies in the cervix. These are seen on the surface in little whitish pearl-like projections, which give a strong contrast to the deep reddish color of the membrane. This condition is sometimes referred to as cystic degeneration of the cervix and may do great harm, as these cysts may become so large, that by pressure they destroy large portions of the cervical wall. If the cystic degeneration is present, the cervix will be greatly enlarged, sometimes enor-

mously so. The cervix as a whole is generally not sensitive to the touch, but the canal is quite sensitive to the introduction of a sound.

The only electrical treatment indicated in the acute stage of endometritis, if indeed any at all is required, is a vaginal application, either with the bipolar vaginal or abdominal electrode of the faradic current of tension. This will produce immediate relief if the symptoms are grave enough to cause much distress. The application may be made once or twice a day if the severity of the symptoms demand it. This, in addition to the relief it affords, will help on the menstrual flow which generally comes on under these conditions ahead of time, and, when it does appear, is apt to afford great relief.

The present methods in vogue in the treatment of chronic cervical leucorrhœa are nearly all based upon some form of cauterization. We have a double caustic in the galvanic current, the positive acid caustic and the negative alkaline caustic, which may be controlled at will. It is a question, however, whether a simple caustic of any kind permanently cures a case of cervical leucorrhœa, and if electrolysis had a caustic effect only, we should not recommend it. A caustic applied to the surface simply stops the discharge by contracting the blood vessels and destroying to a greater or less degree the diseased tissue, and some of the other forms of caustics act more quickly in these respects than does electricity and are easier of application.

Of course, this is very desirable and must be done in order to cure a case of cervical endometritis, but in all cases that are of long standing there are deep seated changes, and if these changes are not brought back to a normal state, they are in condition to act as a nucleus to reproduce the same state which existed before the caustic was applied. In the electrolytic and catalytic action of the galvanic current, we have an agent by which we can reach these deep seated changes.

Care should be taken to first remove the secretion by means of the curette or some other method, so that the electrode used will come in contact with the surface of the diseased

membrane. An electrode should be chosen that will completely fill the cavity of the cervix, and come in contact on all sides with its walls, and to this is attached the negative pole. The positive electrode is placed on the abdomen in the form of a clay pad and a current given strong enough and long enough to produce cauterization of the entire cervical membrane. A hundred milliamperes used from five to eight minutes will suffice; but if less current is used, it must be continued longer. This will produce some bearing down sensation, but as the application is of short duration, it will generally be borne without complaint. This is for the purpose of cauterizing the membrane, and it is better to allow the patient to remain for one week without further molestation. After that time the same treatment, except as to polarity, is to be repeated once or twice a week, only a much weaker current is used, not more than 25 milliamperes being required.

As has been stated, the cauterizing should always be done with the negative pole, but not so with the after-treatments. An indication has been given, and it is a good one, that if there exists a very soft relaxed condition, the positive pole should be chosen, but if there exists a cirrhotic condition, the negative should be used. Some employ a combined method in treating these cases. They use an easily applied caustic, such as chromic acid, to produce the heavy cauterizing effect, and then go on with the electrical treatment afterwards, to influence the deeper tissue changes. The discharge will stop very soon after the cauterization, providing it has been sufficiently thorough, but the treatment should be continued for from one to three months afterward, according to the severity of the attack and the frequency of the treatments.

When cystic degeneration is present, it requires an entirely different form of treatment. After a speculum has been introduced and the cervix brought into view, a long, thin needle attached to an insulated handle, which is connected with the negative pole, is thrust deep into the cyst, the projecting portion of which can be seen by the whitish, pearl-like spot, or may often be felt with the finger. A current of from ten to

twenty-five milliamperes should be used for from five to ten minutes in each cyst. The depth these needles are to be introduced will depend upon the depth and size of the follicles, but generally from one-sixth to one-eighth of an inch suffices. Each follicle will be cured by one application, if the current has been of sufficient strength and duration.

Massey claims to have had excellent results with his method of cupro-mercuric cataphoresis. He uses a copper sound which has been amalgamated by being dipped into mercury and rubbed with moist cotton. To this he attaches the positive pole, while the other is placed over the abdomen, giving a current of from 35 to 40 milliamperes and repeating the treatment twice a week.

We have used iodine in a similar way with excellent results, only the iodine should be dispersed from the negative electrode, as it goes from the negative to the positive pole.

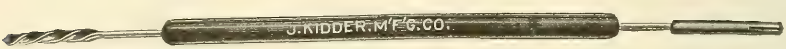


FIG. XX. Electrode for Applying Iodine, Cataphoricly to the Cervical Canal.

A light film of cotton is wrapped around a sound, and is saturated by dipping it into iodine. This is introduced into the cervical canal and attached to the negative pole. The positive pole may be placed over the abdomen. Twenty-five to forty milliamperes passed for ten minutes, will cause all the iodine to disappear. We recently cured a very severe case in less than three months by making these applications twice a week. In this case, however, the severe cauterizing treatment was first given, as recounted above.

Corporal Endometritis. There seems to be great confusion regarding corporal endometritis. This is due in part to the fact that it is very difficult at times to diagnose and has become mixed up with other inflammatory diseases. Corporal endometritis may exist conjointly with cervical endometritis or it may exist independently, and should be diagnosed as such, when it does so exist. It is very difficult to know the

exact pathology of corporal endometritis, as it cannot be seen; and, as it never proves fatal, post mortem appearances are not to be relied upon. It is, however, very probable that the changes are similar to those of cervical endometritis, being an essentially glandular disease. The glands become greatly enlarged and may set up a cystic degeneration. The internal os may become partially closed from the increase of the connective tissue. Sometimes there is an hypertrophy of the mucous membrane, throwing off little polypoid projections, described in books as polypoid endometritis. Accompanying this, in the advanced stage of the disease, are the so-called granulations, vegetations or fungosities. The walls of the uterus in long-standing cases may be found to be thinner or thicker than normal, but this is seldom marked. There may be irregularity of the menstrual flow with great pain. It may be scanty or suppressed, but these are the exceptions. The rule is that the flow is very profuse, hemorrhagic, and accompanied with great pain. On passing a sound into the cavity of the uterus it is found to be very sensitive, especially at the internal os and fundus. The cavity will also be found to be larger and the membrane will show a great tendency to bleed on the slightest touch.

To no other disease has electricity been a greater boon than to corporal endometritis. It is of greater importance in the treatment of corporal than it is of cervical endometritis, for with the latter other methods of treatment are of avail. Applications of any kind may be made to the cervical membrane without fear, but it is more dangerous, as well as less effective, to make local application to the corporal membrane. The electrical treatment varies with the stage of the disease. The congestive form needs only a light application of galvanism to the endometrium about twice a week, the strength of current varying from 25 to 50 milliamperes, for five or eight minutes. The selection of the pole should be governed by the amount of hemorrhage or the profuseness of the flow. If it is decreased, the negative; but if profuse, the positive. It follows that the positive will generally be the one indicated. A cure

may reasonably be expected, if a simple congestion alone exists, in from one to three months. In the congestive stage we get only a very slight cauterizing effect; for this is all that is needed, as the disease is not deep seated, and the glands are very favorably affected by the catalytic action of the current. As the disease advances and gets into the hypertrophic stage it is necessary to cauterize the membrane more thoroughly in order to reach the deeper seated diseased tissue. Here the current should be crowded to at least 100 milliamperes. At this stage, there may be dried secretions over the membrane, thus preventing the electrode coming in contact with the membrane itself. In this case, attach the negative pole of the battery to the electrode when it is first introduced, for from

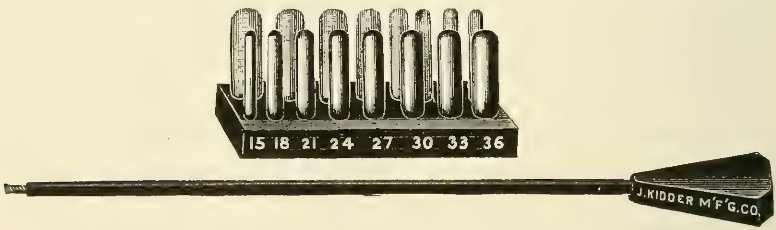


FIG. XXI. Electrodes for Producing Metallic Electrolysis.

one to three minutes. This dissolves the hardened mucus, allows the electrode to come in contact with the membrane, when the current may be reversed, of course after it has been reduced to zero *for never reverse or change a current in any application to the uterus until it is first turned off*, so as to prevent a shock to the patient.

A more rapid method of treatment is to use the curette to first remove the debris and then proceed with the electrical treatment in order to effect the deeper changes. The fungus may, however, be destroyed by means of metallic electrolysis, using a large-sized copper or zinc electrode. Here, also, the use of iodine on the negative pole as recommended for cervical endometritis will be found to be most efficacious. It is, however, impossible to introduce the cotton-covered electrode through the internal os unless it be greatly dilated and it

would, even in that case, be dangerous as the cotton might be left inside the uterus. Here an electrode, so constructed that a cap of hard rubber perforated to allow the iodine to escape, screws tightly over the cotton, thus obviating all danger, should be used.

There are gynæcologists who insist that the principal thing in curing endometritis is to keep the internal os dilated so as to allow drainage of the cavity. In many of the worst cases there is an atrophy of the membrane and the internal os is larger than normal, thus leaving plenty of room for drainage, yet the patients do not get well. However, where the internal os is closed or encroached upon by the thickened membrane, it is very essential that this be thoroughly opened before beginning treatment, so as to allow easy drainage for the diseased tissue that is thrown off. It is easy to understand that the damming back of this dead tissue would produce great harm.

The introduction of the uterine electrode does not differ in any particular from the introduction of the uterine sound, but a few rules regarding it may assist the beginner.

First: Have the patient take an antiseptic injection of some kind before introducing the electrode. If treatments are given in the office, which is generally the case, have this done before she leaves home.

Second: Have the electrode thoroughly aseptic.

Third: Introduce the index finger of the left hand and place the bulb just against the external os. With the right hand, using the finger in position as a guide, introduce the electrode. When it is in the cervix it is best to press the handle slightly downward as it will slip through the internal os better unless there is a misplacement, when it is necessary to find out the direction of the canal by manipulation. Never use the speculum for this purpose if it can be avoided.

Menorrhagia and Metrorrhagia.—It is probable that few cases of uterine hemorrhage exist which are not due to an endometritis of some kind, unless, of course, there be retained portions of a fetal sac or neoplastic growth. There are, however, cases where the last two causes can be safely discarded and where

there is no leucorrhœa but where the patient suffers from a profuse menorrhagial discharge every month. This may be due to a relaxed condition of the uterus, as it is generally found in neurasthenic subjects, or it may be due to a hemophiliac tendency of the patient. If the former, the principal dependence for a cure must be placed on the building up of the general condition, for which we refer the reader to the article on neurasthenia. It is, however, very important to stop the excessive flow as soon as possible, as the anæmia produced each month aggravates the neurasthenic condition and makes it much more difficult to cure. Then, too, the relaxation of the uterus may be more or less of a local character. The treatment here is to introduce the bipolar uterine electrode well up into the uterus and pass a very strong faradic current of quantity. This will set up a vigorous contraction of the uterine walls, which, of course, does not all remain; but by repeating the treatment twice a week for a few weeks, sufficient tone will be given to the uterus to relieve the menorrhagia, providing relaxation be the sole cause. Occasionally, however, this treatment will not entirely relieve the excessive flow; when this is the case, applications of the galvanic current—the positive internally—will be very sure to complete the cure. Here it is probable that the capillaries of the endometrium have become dilated, and therefore have a tendency to hemorrhage, and it is necessary to get the positive galvanocaustic action on it. The same precautions requiring the selection of a large-sized sound, one that completely fills the entire cavity, and the thorough cauterization of the membrane, are needed as are mentioned in corporal endometritis, to which the reader is referred. Massey claims that by his cupromercuric cataphoric method,—that is, using a copper sound which has been amalgamated with mercury instead of the ordinary sound, and which, he claims, carries the mercury into the tissue by cataphoresis,—he can cure these cases much quicker.

Subinvolution. The rapid enlargement of the uterus during gestation and its more rapid decrease after confinement, have

no parallel in the animal kingdom. The uterus, which normally weighs only two ounces, at the culmination of gestation weighs about two pounds, and if involution is carried on in a normal manner, it returns to its former size in about three weeks. If the cervix is found to be large, soft and very congested, and bimanual examination reveals the uterus to be large, soft and compressible, the condition is of recent origin and recovery will be rapid and complete. If the subinvolution is allowed to remain for months after parturition, the uterus gets into a condition which resembles chronic metritis. It will then be found that the cervix is anæmic instead of congested and the whole uterus is large and hard instead of soft and compressible.

The method of treating a recent case of subinvolution by

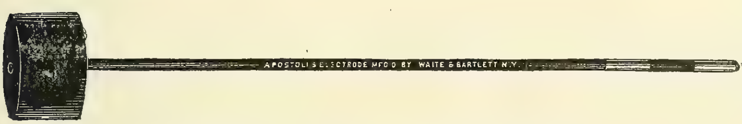


FIG. XXII. Double Uterine Electrode.

electricity is both simple and effective. The double uterine electrode, is placed inside the uterus, so that a current passes from one end of the organ to the other. A strong current from the secondary coil of quantity should be allowed to pass for from five to ten minutes, when the uterus will be found contracted and the cavity much smaller than before the treatment. Of course all this contraction does not remain; but abundant experience proves that part of it remains, and, by giving a treatment two or three times a week, in a few weeks a large subinvoluted uterus will be reduced to its normal size. If, however, the disease is of long standing and the uterus has become hard, it should be treated by galvanism, and as this treatment does not differ from that laid down for chronic metritis, the reader is referred to that section.

The great importance of beginning treatment early in these cases, while the faradic current is still of avail, is illustrated by

the three following cases, taken from our case book. One came under treatment nine weeks after confinement. The uterus was large and soft, the canal measuring 4½ inches in length. After three treatments with the faradic current, it was reduced to 3½ inches, and after the seventh to 2¾ inches. Treatments were given every third day. With the second case, treatments were begun twenty weeks after confinement, the uterine canal measuring 4½ inches. At the fifth treatment with the faradic current, it measured 4¼ inches, at the seventh treatment, 4 inches, at the fifteenth treatment, 3½ inches, and at the twenty-first treatment, 3¼ inches. The third case was of one year's standing, very hard and incompressible. After ten weeks' treatment three times weekly with a galvanic current, it measured 4 inches plus; after four months' treatment it measured 3¾ inches; after six months' treatment the same.

Superinvolution.—It sometimes happens that the process of degeneration, which has been described as involution of the uterus, is carried too far, and the uterus is reduced to below the normal size. This is a very rare disease, and one which is not well understood. We are indebted to Sir James Y. Simpson for first describing it, and so little has been learned regarding it since his day that recent authors quote his remarks. If the uterus is smaller by measurement than when in a normal state, and bimanual examination finds it small, soft and compressible after parturition, it may be a case of atrophy of the uterus due perhaps to some indiscretion on the part of the patient after confinement, but it is generally due to some organic disease of the ovaries. These atrophic conditions, as a rule, give rise to no suffering. The physician may be consulted by the patient for a sterility or amenorrhœa, and an examination reveals for the first time that there is an atrophic condition. The same treatment as is described under amenorrhœa for lack of development is required here. When the atrophy is due to disease of the ovaries, treatment is useless, but when due to outside causes, if the patient is not over thirty years of age, hopes for a recovery may be entertained.

Chronic Metritis.—This disease is described under various names: hyperplasia, sclerosis of the uterus, etc. It consists of an increase in the connective tissue of the uterus. This increase of connective tissue generally begins in the middle coat of the uterus and may go on increasing until it involves the entire organ. It encroaches upon the muscular coat and blood-vessels. The uterus is always first enlarged, but in cases of very long standing, it is of normal size or even smaller than normal. This is because the increase of connective tissue so encroaches on the muscular tissue and the blood-vessels, thus cutting off the blood supply, that it produces atrophy. The symptoms during the intermenstrual period in metritis are not characteristic and there is apt to be amenorrhœa or a very scanty flow. This scanty flow is always accompanied with more or less distress.

While electricity is an improvement on former treatments indicated for chronic metritis, its results are far from being satisfactory. If the disease can be detected in the early stage, the stage of hyperæmia, before sclerosis has made its appearance, the positive pole should be used internally and a current of from 50 to 150 milliamperes given from one to three times a week, according to the strength of current used and ability of the patient to bear the treatment. The weaker the current given, the more often should it be administered. It is, however, difficult to recognize the disease in the early stage unless it follows some other disease which sets up the hyperæmia and which should be treated according to the condition present. The negative pole, with its great catalytic, distrophic and resorbent effects, makes it indicated in this disease after sclerosis has set in. The treatment should not differ from that given for fibroid tumors, with the negative pole attached to the internal electrode while the positive connected with a clay electrode is placed either over the abdomen or over the lumbar region. At the first treatment 50 milliamperes may be given, but this strength may be gradually worked up up to 100 or 150 milliamperes, if possible. The treatment should be given from five to eight minutes. Treatments need

not be given oftener than once or twice a week. There is no disease where greater care, gentleness, and skill in manipulation should be observed than in chronic metritis. The electrode should be very gently introduced, and, if it causes pain, allowed to remain in place until the pain passes off, before turning on the current. The operator should be careful not to produce too much pain, only such as can be easily borne. If there is pain after the current is turned off, the faradic current of tension may be given before removing the electrodes, or, if they are removed, the bipolar vaginal electrode may be used with the same current.

Fibroid Tumors—Fibromyomata.—The ordinary classification of fibroid tumors into sub-peritoneal or those lying between the walls of the uterus and the peritoneum; the sub-mucous or those lying between the walls of the uterus and its mucous lining, and the interstitial or those within the wall of the uterus, is necessary to the clinical selection of cases for electrical treatment. Sub-peritoneal tumors are not reducible by electrical treatment. It is claimed, however, that if they have a tendency to become pedunculated the treatment will, by contracting the muscular walls, hasten this process, and thereby cut off nutrition and arrest the growth of the tumor. This, however, is questionable. Some authors think the interstitial variety is the most reducible by electrical treatment, but this has not been our experience. It has been with the sub-mucous tumors, that we have achieved the greatest success. Here we get the local action of the current upon the endometrium and the tumor which lies underneath it. Rarely in sub-mucous tumors do we fail to relieve the symptoms, and in every case the relief of the symptoms is far greater than is the reduction in the size of the tumor. The cases in which the treatment will not be so successful are the very hard variety and the very soft variety. Those tumors which have a gelatinous feel and are to a degree erectile, being very large just before the menstrual flow and decreasing rapidly during its continuance, are not much benefited. Neither is the fibro-cystic variety successfully treated. Those of a normal elasticity, not hard nor soft,

are the most reducible and their symptoms are most promptly relieved. There are certain symptoms which contraindicate treatment even in this class of cases. If there should be a slight ovaritis, weak currents of not over fifteen milliamperes may be given in order to relieve some symptoms, but with no expectation of much reduction. However, if there should be any suppurative disease, or a chronic inflammation of the Fallopian tubes, even a hydrosalpinx, electrical treatment should not be undertaken.

The electrical treatment of fibroid tumors is divided into the intrauterine treatment, called by the French the galvano-caustique, and the puncture treatment. The former consists

FIG. XXIII. A Set of Aluminum Electrodes for Uterine Application.

in placing a large clay electrode, or an electrode of any other material capable of carrying a sufficient amount of current without too much burning, over the abdomen, or if the tumor is in the posterior wall, on the lumbar region. However, as a rule, the tumors in the posterior wall flex the body of the uterus forward, so that one electrode on the abdomen and one inside the uterus bring the tumor between them. The active or intrauterine electrode should be carefully selected. If the negative pole is used, and it should always be employed unless contraindicated by some cellular inflammation or hemorrhage, it may be made of copper, silver or any other suitable material. If the positive is employed, and that is indicated by a cellular inflammation and hemorrhage, it may be made of platinum, carbon, gold, iridium or aluminum. There is a

slight action of the positive pole upon aluminum, but it is so very slight that it need not be taken into consideration, and by a little care, aluminum can be used with perfect safety on the positive pole, even with the strongest currents. In every case, the electrode selected should be large enough to come in contact with both walls of the uterus. If the internal os is contracted so that such an electrode cannot be used, it should first be dilated for it is the local action far more than the interpolar action which produces the desired effect. When the positive pole is used to relieve hemorrhage, the treatment will be worthless unless this precaution is taken, for it is the local action of the current of the positive pole upon the endometrium which causes cicatricial contractions and relieves the hemorrhage. The reason so many failures have been reported in relieving hemorrhage is the fact that the expensive electrodes were not made large enough to fill the uterus. With aluminum electrodes we have such a cheap material that various sizes may be easily obtained and we no longer have any excuse for not using a proper-sized instrument.

The currents should be gradually turned on and as gradually turned off, so as to prevent the least shock to the patient. Treatment may continue for from five to eight minutes; it should never be given more than three times a week and generally twice a week is preferable. The strength of current should not be less than 100 milliamperes when a non-insulated electrode is introduced into the entire uterine cavity, and 175 milliamperes may often be reached if the patient is handled with due care. There are patients who cannot bear this strong treatment; in such a case, treatment may be given under an anæsthetic. We have given as high as 600 milliamperes for from ten to eighteen minutes under an anæsthetic to relieve a hemorrhage; it has in every case been successful, and has not the least bad result, with one exception in which there was a slight metritis lasting for three days with a temperature ranging from 99½ to 100.

The uterine cavity may, however, be cauterized in sections, using a small tipped electrode, and as the current density is in

proportion to the surface it acts upon, a much weaker current will cauterize the exposed section. When one section has been thoroughly cauterized the exposed part of the electrode may be removed to a new section, and so on until the entire surface of the uterus has been covered. The treatment should always be given under the strictest of antiseptic precautions.

The puncture treatment, so much in vogue a few years ago, is but little used to-day. While we have made upwards of eight hundred abdominal punctures and have never had what might be called a serious symptom following one of them, we believe the treatment is not successful, and we have, therefore, omitted the description of it.

Prolapsus, Versions and Flexions.—The objects of electrical treatment in uterine displacements of various kinds are, first, to relieve any chronic inflammation which may exist, whether it be in the uterine walls, the endometrium or the cellular tissue surrounding the uterus, and second, to restore tone to the uterus and its supports. Not infrequently is perimetritis or parametritis present, and no active treatment to reduce the misplacement should be begun until the sensitiveness has been removed by proper treatment. The same is true of endometritis and metritis, and when present they should receive the proper treatment; but perhaps in this case, some efforts at replacement may be made at the same time, as the misplacement may be the cause of the metritis. The treatment covering these conditions is to be found in other places.

In treating uterine misplacements and flexions by electricity, we must depend largely on the action of the current upon muscular tissue. It will be seen, therefore, that in flexions where the trouble is chiefly in the muscles of the organ, we have a powerful remedy, but not so with versions and prolapsus, for the muscular tissue is very scantily supplied to the supports of this organ, and, consequently, we have not the same advantage here as in flexions.

The first effect of the treatment should be to relieve the engorgements in displacements. According to Tripier, it is the principal object to be attained. He applies one electrode in

the uterus and the other in the bladder or rectum according to the displacement and uses the faradic current exclusively. He gives very minute details for faradization in these conditions. It is rather difficult to see what merit this method possesses over the bipolar uterine treatment, or the utero-abdominal and utero-sacral applications and it certainly has many disadvantages in its inconvenience, in the pain which is produced by it, and in the danger accompanying it. The relief of the engorgement is probably due entirely to muscular contraction, toning up the uterus and relieving the venous engorgement. This is best accomplished by the bipolar uterine electrode, using the faradic current of quantity, unless contra-indicated by pain or sensitiveness, when the current of tension or the medium current should be used. When the sensitiveness disappears, the current of quantity should be resorted to. This treatment may be given daily, or every second day, for about five minutes' duration. The patient will feel lighter; the disagreeable sensations, such as bearing down, etc., disappearing almost immediately after the treatment. All the contraction will not remain after each treatment, but a certain amount will, leaving the uterus much less congested; by persistence, a final cure is reached.

The treatment for a displacement consists in giving both the faradic and galvanic or the sinusoidal current either to the uterine cavity or through the posterior cul-de-sac. The greatest tonic effect is produced by giving the galvano-faradic. (See General Electro-Therapeutics.) If there is any sensitiveness the positive pole of the galvanic current should be used internally; if not, the negative. A clay-covered ball electrode is introduced into the posterior vaginal cul-de-sac, with the external electrode over the abdomen, using a current of about thirty milliamperes. The faradic current is governed by the sensation of the patient. The medium coil is used.

When adhesions are present in retroversions, much may be accomplished in reducing them. Here the intrauterine electrode is introduced into the uterus, the external electrode being placed over the sacrum. The internal electrode should

always be the negative unless contraindicated by sensitiveness and hemorrhage; and a current from twenty to thirty milliamperes should be passed for about eight minutes. After the first few applications, slight pressure should be made upon the uterus, thus making a certain amount of traction on the adhesions. If they are not too strong, they will finally give way. This treatment will prove most successful in connection with other well known gynæcological expedients.

With flexions we obtain more definite results. Here it is necessary to have a number of electrodes varying in size from number six to number twenty, French scale. The aluminum electrodes described in endometritis will answer the purpose very well, but it is necessary that they be kept well polished. They should be so bent that it is possible to pass them, by the aid of electrolytic action through the flexion. Beginning with the smaller electrode, it is introduced up to the point of the obstruction; then turn on about fifteen or twenty milliamperes, all the time making gradual pressure on the electrode until it works its way through the obstruction. The small sized electrode should be used in after-treatments until it is easily introduced to the fundus, when the next size larger may be selected. It will be found that the negative pole not only tones up the muscular walls of the convexed surface of the uterus, but it softens the hardened sclerotic tissues of the concaved surface. The mechanical introduction of the sound undoubtedly assists the electricity in this respect. Faradism may be employed, the bipolar method especially, with advantage, and the sinusoidal current by its great power over muscular tissue will assist much in giving tone to the walls. In fact, after the number ten electrode, French scale, passes freely, other treatments may be given with bipolar faradization using the current of quantity or with the sinusoidal current. The best treatment is to combine the two. Give first the galvanic for five minutes and the bipolar faradic or sinusoidal for five more. If the patient can take treatments frequently, it will even be better to give the galvanic for eight minutes on one day and the faradic or sinusoidal for eight or ten minutes the next day.

We have seen many cases of sterility due to flexions, cured by this method of treatment. In fact, in recent cases it is very successful, and even with the most chronic cases it is capable of relieving pain and suffering during the menstrual flow, and toning up the pelvic organs to the degree of relieving many, if not all, of the disagreeable symptoms which generally accompany flexions.

It is not uncommon to find an endometritis present in uterine misplacements and when it does exist, it should be treated according to the methods given in another part of this section.

Amputation of the Cervix and Removal of Uterine Polypi.—The advantages of the galvano-cautery in the removal of the cervix and uterine polypi are: First, it is antiseptic, as the heat employed is enough to destroy any germ life; and, second, it obviates all danger of hemorrhage. However, in that class of polypi which have an attachment high up in the uterine cavity, it is very difficult to apply the cautery loop, as the platinum wire used is very flexible and has to be put in position with a director, whereas the steel wire of the ordinary ecraseur being stiff, holds its shape perfectly and is much easier to apply.

The method of operation is very simple. The wire is made to encompass that part of the cervix where the amputation is to be made, or the neck of the polypus close to its attachment. The method of handling the loop in these cases is the same as that given for amputation of the tongue, to which the reader is referred for the technic.

Peri-Uterine Inflammations.—So far as the electrical treatment of these pelvic inflammations is concerned, it does not matter whether there is a general cellulitis or pelvic perimetritis; the principle involved in the treatment is to reduce the inflammation, absorb deposits and break up adhesions that have been formed, thus relieving the parts from the products of the inflammation.

Apostoli in 1887 recommended an electrical treatment for the acute inflammatory stage of pelvic cellulitis. This is quite contradictory to the principle that electricity is contraindicated

in acute inflammations of any kind. His method of application in the acute stage is to use the double vaginal electrode, the one pole of which is placed in as close proximity to the inflamed part as possible. The faradic current of tension is employed. At first it should be imperceptible and gradually increased, but never sufficient to aggravate the pain in the slightest degree. The length of time the application is to continue should vary with the severity of the pain. It should always be given until the pain is relieved, and this may require fifteen minutes, or even more. He gives very emphatic advice regarding the care and gentleness which should be exercised in this treatment, so as not to injure the inflamed parts. He claims it relieves the pain, the relief continuing longer after each treatment, and besides this sedative effect, it has a very marked action in arresting the inflammation, cutting short the attack, and thus preventing suppuration.

FIG. XXIV. Bipolar Vaginal Electrode.

With all due respect to this high authority, we are bound to state, that after making the attempt in several cases, and with the greatest possible care, we have seen no benefit from this treatment during the rising stage of the inflammation. The relief from pain during this stage, between the treatments, is of but short duration, and when it returns, either by comparison with the short period of relief, or, as we are prone to believe, owing to a slight increase of the inflammation, it seems to the patient to reappear with redoubled energy, while the frequency with which the application must be made tends to aggravate the condition, rather than to relieve it. However, when the inflammation is subsiding, when it is on the downward grade, this treatment, if carefully given, will have a very marked effect in relieving the pain. Here the period of relief will continue longer after each application until once or twice a day will keep the patient in a very com-

fortable condition; and this treatment should be continued until all excessive soreness has disappeared.

The next stage in the treatment is to insert in the posterior vaginal cul-de-sac, a carbon ball-electrode covered with clay and chamois, to which is attached the positive pole. If a node can be found, the electrode should be pressed firmly against it. The negative electrode should be a large one, so as to diffuse the current, and should be placed over the abdomen. Not more than eight or ten milliamperes should at any time be given, continued for ten or fifteen minutes. If this treatment aggravates the case, or fails to produce at least some relief, it has been begun too early, and a return to the bipolar vaginal treatment should be made.

After all sensitiveness has disappeared, or nearly so, a

FIG. XXV. Carbon Ball Electrode.

platinum or aluminum electrode may be introduced into the uterine cavity, and the treatment given the same as with a ball-electrode, positive internally, and from fifteen to twenty-five milliamperes given for ten or twelve minutes. If this treatment is well borne, the negative pole should be attached to the internal electrode, as soon as posible, as its efficacy in dispersing inflammatory deposits is greater than that of the positive, but as it is more stimulating and more liable to increase congestion, care should be taken not to use it until the disease has passed into a thoroughly chronic state.

If after two or three months of treatment with the negative pole there seems to be no improvement, the galvanopuncture should be resorted to. This, of course, is not done until the disease has become thoroughly chronic. The number of punctures required varies with the extent of the disease. One puncture may cure a slight parametritis, while three or four may be required to reduce a general cellulitis.

The method of operating is as follows: After locating the exact point of the inflammatory deposit with the finger, the hard rubbei shield is placed in a position so that the end comes directly against the deposit. The sharp pointed electrode, which should be very small, is now passed through the shield into the substance of the tissue, care being taken to introduce it in a direction so as not to involve the peritoneum, bladder or other organs. It should never be inserted for more than a quarter of an inch, and ten to fifteen milliamperes may be given for from five to ten minutes. In a few days contraction will take place, an eschar will separate and a slight exudation will appear. The patient should be kept in bed for two or three days, when she will be able to go about without harm. With all treatments a vaginal douche is given, both before and after, and the vagina packed with some antiseptic gauze. When a case has been unfortunate enough to go on to suppuration, we may also use the galvano-puncture to advantage, providing the point of suppuration be determinable and it lies sufficiently low so that it can be penetrated. Here a puncture is made with an uninsulated needle into the pus cavity, and a current of twenty-five milliamperes passed for at least twenty minutes, thus making drainage for the cavity. The advantage derived from this is that the electrolytic action of the current on the walls of the canal prevents its closing readily, thus keeping it open for drainage, while the same electrolytic action protects the walls from absorbing the pusas it flows through. This, however, should not be undertaken without a thorough knowledge of the locality of the pus cavity, which can, as a rule, only be obtained through the feeling of a fluctuating point.

Ovarian Irritation and Inflammation.—There is a form of neuralgia of the ovaries which appears in young girls and also in recent widows, manifest by acute pain and soreness, but not specially sensitive to pressure. This is quite readily relieved by a strong static spark over the ovarian region, but seems to baffle internal treatment with either the galvanic or faradic current. There is another form of ovarian irritation that is

not manifest so much by the acute pain as it is by a distressed feeling, rather indescribable, so far as the pain is concerned. This is probably due to a slight congestion which is very readily relieved by the faradic current of tension when administered by either the bipolar vaginal electrode pressed well up on to the ovary, or by a vaginal ball electrode and a flexible hand electrode placed over the ovarian region.

The distinction between the various manifestations of ovarian irritation, where the one form of electrical energy is more beneficial than the other, is still very confusing; and we are unable to distinguish, or to give rules which will invariably lead one to the best current to use. However, if one form of treatment does not relieve promptly, it is better to try another. This confusion is undoubtedly due to a lack of knowledge of the various conditions present in the so-called ovarian irritations. Perhaps some of them are reflex, while others are congestive, all giving rise to indistinct symptoms which we sum up in the unknown quantity of ovarian irritation, or ovarian neuralgia.

With chronic inflammation of the ovaries, we have a more definite field to work on. Here we know the pathological condition. In cystic degeneration of the ovaries electricity is not indicated; but in those chronic congestions manifest by ovarian dysmennorrhœa, fixed and constant pain over the ovaries, painful intercourse, with sometimes inability to stand or walk, exhaustion and all the other symptoms of a chronically inflamed ovary, electricity will surely be beneficial. Some recommend the faradic current of tension, using either a bipolar vaginal or uterine electrode, or the ball and surface electrode, so placed that the ovary is brought between them, and consequently in the electric field. If the inflammation is at all acute this treatment may be employed, but in the very chronic stages galvanism is far superior. It is necessary in the first place to get the positive electrode, which is a clay covered carbon ball, as near the inflamed ovary as possible, (sometimes when the ovary is prolapsed this can be done better by introducing it into the rectum) and also to so place

the electrodes that the ovary comes directly within the electric field. If there is a prolapsus, the ovary should be returned to its normal condition. All hygienic methods should be employed, and perhaps a tampon saturated with boro-glycerine may be necessary to assist in removing the congestion, and to help retain the ovary in its position. The electrical treatment may be given two or three times a week, varying in strength from twenty to forty milliamperes, according as the patient is able to bear the current. If the ovaries are especially sensitive the faradic current of tension may be switched on to the same electrodes, and a current passed for three to five minutes. This will relieve the sensitiveness very much. If both ovaries should be inflamed it would be better to treat them alternately.

This treatment greatly relieves the symptoms, and it is therefore to be supposed that it relieves the congestion. It also has a tendency to break up adhesions by absorbing any deposits which may have been thrown out. Certain it is, that some of the most chronic cases of ovarian distress have been and can be thus relieved.

Inflammation of the Fallopian Tubes.—It is often impossible to diagnose between ovaritis and salpingitis, and from a therapeutic standpoint it is of no importance providing the tubal in-inflammation is of a simple or catarrhal form, as the treatment in both cases is the same. Care should, however, be exercised to distinguish a hydro-salpinx and especially a pyo-salpinx, for with the latter the treatment will not only be of no avail, but may be injurious.

Menopause—Climacteric.—Larat strongly commends the use of electric baths to combat symptoms of the climacteric. The treatment soothes the nervous system, improves the circulation and diminishes local congestions, causing a general amelioration of all symptoms.

OBSTETRICS.—**Ectopic Gestation.**—This very dangerous condition is fortunately treated by electricity with great success, providing the diagnosis is made before the fourth month, —that is before rupture. After that period, however, it is a question whether electricity should be employed, or rather

abdominal section. The great danger of rupture of the sac is reduced to a minimum if the operation is performed before the third month, and is comparatively slight before the fourth. Electrical treatment of ectopic pregnancy should also be confined to the tubal variety only, but as this is far the most frequent form and as no harm can come from the ovarian, if such a condition be possible, or tubo-ovarian, if the diagnosis of extra-uterine pregnancy be made before the sixteenth week, electricity should be resorted to. Electricity is not entirely barred from use after rupture of the sac, for when the rupture has taken place into the broad ligament and then continues to grow, without symptoms of an internal hemorrhage, electrical treatment may be used to destroy the life of the ovum and to assist absorption. It is especially useful in this condition as abdominal section has proved very fatal.

One of the strongest recommendations for electricity in the early stages, aside from its almost universal success, is that in the event of a mistake in the diagnosis no harm is liable to result; for when the electrical treatment has been abandoned for laparotomy, seldom is anything found of an injurious character. This is more than can be said for any other treatment. When regarded in the light of the difficult diagnosis, this is certainly a strong recommendation for electricity. The only exception to this statement with which we are acquainted, is in a case recently reported by Dr. Egbert Grandin, who, after treating a case of ectopic gestation with electricity, with apparent success, eighteen months after performed a laparotomy for the same in the other tube when it was discovered that the tube first treated had developed a pyo-salpinx.

There has been much discussion regarding the method of treatment to be employed. Every one claims superiority for his own method, some asserting advantages for the faradic, while others assert the same for the galvanic. As a matter of fact, either form of current will produce the desired result when given in a proper manner, and of a sufficient strength. The galvanic current, however, is far more certain in its action. The surest method is to introduce a vaginal clay-

covered ball-electrode well up against the tumor, and a good sized clay-electrode on the abdomen, so as to bring the ovum directly between the two. The current may be gradually turned on until 100 to 150 milliamperes is reached, at which point it is allowed to remain for six or seven minutes, then reduced to twenty milliamperes and a few alternations made. This will produce disagreeable shocks to the patient, but if she is properly warned, it will do no harm. This method, while being more certain in its action than any other with which we are acquainted, should be confined to the period before the third month, as later, the alternations are liable to produce rupture. After the third month, treatment may be given by gradually raising the current to 100 or 150 milliamperes, where it is maintained for a minute, then gradually reduced to the zero point when the polarity is reversed and the current again raised to the above point and again reduced, following this order until four or five reversals have been made at each treatment. Here no shock is produced, the current being reversed only when the pointer is at zero This treatment may be given every day, or every other day, until a shrinkage is noticed in the size of the tumor, which is proof that the ovum is destroyed. After the destruction of the ovum the treatment should be continued without the alternations, and with the negative pole attached to the internal electrode so as to facilitate absorption. The faradic current may be employed but is more uncertain in action, while the opposite is true when it is desired to produce an abortion. With the ovum properly located as in the latter case, we get the greater stimulating contractile power of the faradic current on the muscular walls of the uterus, which is not only not needed in ectopic gestation, but adds a degree of danger by making rupture more probable. The use of both the galvanic and the faradic currents have been recommended. First give the galvanic as described above and then switch the faradic on to the same electrodes and pass for a few minutes a faradic current to the point of tolerance.

The puncture treatment as recommended by Apostoli is both dangerous and unnecessary.

Four cases have been reported where under the electrical treatment muscular contractions of the tube have forced the ovum into the uterus, when it has been delivered through the normal channel; one case where it has been forced through a rent into the vagina and another into the rectum.

This treatment should be considered in the light of an operation, and should always be performed at the bedside and not at the office. We do not feel it necessary to enter into a discussion by comparing this method of treatment with laparotomy. Each seems to us to have its indications in the period of gestation. The theoretical considerations that have been advanced by the enthusiastic operator against electricity, are so completely answered by its universal success, (according to Dr. Brothers' statistics, only one death out of 78 cases) that they need not be considered here.

Vomiting of Pregnancy.—It is a very gratifying fact that some of the most obstinate cases of nausea and vomiting during pregnancy, and those that resist every other form of treatment, will yield readily to electricity. Either the galvanic or faradic current may be used, and if one fails the other should be tried. It is as yet unexplainable, but it will often be found that the galvanic current will relieve when the faradic fails, and *vice versa*. The method of application, however, is the same for both currents. An electrode should be placed on either side of the neck so as to include the sympathetics. Another large sized electrode should be placed well down over the gastric region. When the faradic current is used, the strength should not be sufficient to produce contractions of the abdominal muscles. If the galvanic current is used the positive pole should be placed over the abdomen, and about twenty milliamperes passed. The length of the treatment should be about ten minutes, and when the case is one of great severity, applications may, in the beginning, be made twice a day.

At first the nausea has a tendency to recur, but the inter-

vals will lengthen; then the treatments should be less frequent, until one in two or three days will suffice.

Uterine Inertia.—Dr. W. T. Baird, of Texas, published a series of articles in the American Journal of Obstetrics during the year 1885, in which he set forth the great power of the faradic current to stimulate contractions of the uterus during labor. This was not new, but he also claimed that the suffering from the contractions was made more bearable under the stimulus of faradism, while the contractions were really much stronger; and this was new.

The method of application best suited to these cases is to use large well moistened electrodes, placed on either side of the abdomen just below a line drawn across the navel. The current should be turned on only when a pain makes its appearance, gradually increased for twenty seconds and then gradually decreased as the pain disappears. The stimulation will be noticed after the first two or three applications, when it may be removed if there is danger of laceration from the rapidity of expulsion, but otherwise it may be continued to the end of labor.

Post-Partum Hemorrhage.—Nearly every writer on electro-therapeutics recommends electricity for post partum hemorrhage. We have seen, in our earlier practice, three cases of genuine post-partum hemorrhage, and were we to-day to experience another case with a battery conveniently at hand, we should not dare to wait even to place the electrodes in position.

According to the method advocated by writers on this subject, which is to introduce an electrode inside the uterus, sometimes a double uterine electrode, and at other times a single uterine electrode with an outside pad, the patients in the cases which we witnessed would have bled to death long before the electrodes could have been put into position.

That the faradic current will produce contractions of a relaxed uterus in this state, there is not the slightest doubt; but it would better be used in cases of passive hemorrhage, rather than in an active post-partum hemorrhage.

Abortion.—Electricity is a very successful means of producing abortion, but as it always destroys the ovum it should never be employed in those cases of premature labor where it is desired to save the life of the child. The best method is to carefully introduce a sound electrode, insulated to within an inch and a half from the end, into the uterus and connect the negative pole of a galvanic battery to it, while a clay positive electrode is placed over the abdomen and a current of 40 to 75 milliamperes passed for eight or ten minutes. This may be repeated on the second and third days, when the ovum will be destroyed and begin to shrink. The second day following, a bipolar uterine electrode should be introduced, and a strong faradic current of quantity passed for ten or fifteen minutes. This will set up vigorous contractions and expel the ovum complete. Great care should be exercised not to puncture the sac and to use the strictest asepsis.

Obstetrical Paralysis.—Paralyses produced by protracted labor and consequent pressure and also from traumatism of forceps, are not infrequent. In such cases one or both upper extremities of the infant are usually affected; although facial paralysis may also occur. In severe cases R. D. of a marked type is noted at the expiration of a week, in others, less severe, a diminution of the faradic excitability of the muscles is present, which, unless treated regularly, soon develops into R. D. The treatment is the same as in any other traumatic paralysis (qui vide) with the precaution to use only mild currents of from 3-4 m. a. Mild cases of paralysis respond to treatment in from one to two months; when R. D. is present, upward to six months are required for a cure.

SECTION FOUR.

Diseases of the Alimentary Tract.

Amputation of the Tongue.—When the tongue is the seat of certain malignant growths it becomes necessary to remove it. This does not necessarily mean that the entire organ must be removed but only that portion which is the seat of the disease and this generally can be done by removing a circular portion from the side. As the tongue is a very vascular organ that operation which has the least liability to hemorrhage is best. For this reason the galvano-cautery has won favor, but as will be seen, to insure a bloodless operation even with the galvano-cautery, certain rules must be rigidly followed.

After the patient is anæsthetized—Whitehead's gag or some other instrument suited to the purpose is employed to hold the mouth open—a strong ligature is passed through a healthy part of the tongue and its ends tied to form a loop which is used to handle the organ. The parts to be removed are then thoroughly isolated by running pins, at intervals of one-fourth inch, through the tongue just inside the diseased tissue. The ordinary surgical pins are too long for this purpose and are exceedingly difficult to introduce. A short, round surgical needle is best, and should be introduced with a pair of large needle forceps. The platinum wire loop is then placed behind the needles and the ecraseur tightened.

Mr. Bryant, of England, has, for many years, been the most prominent authority on galvano-cautery operations on the tongue. In a lecture published in the Lancet of February 28, 1874, after giving the preliminary details of the operation, he says: "It (the wire) should not be heated beyond a red heat,

and the redness ought to be of a dull kind. Above all, the process of tightening should be very slowly performed, the wire of the ecraseur being screwed home only as it becomes loose by cutting through the tissues." The lecture from which the above is taken is quoted in part or whole in nearly every text book on electro-surgery, and in a great many works on general surgery; consequently this has become the best known method of operating on the tongue.

It is to the last sentence of the quotation given above that we wish to call special attention, as in that lies the cause of failure of Mr. Bryant's operation, so far as its being bloodless

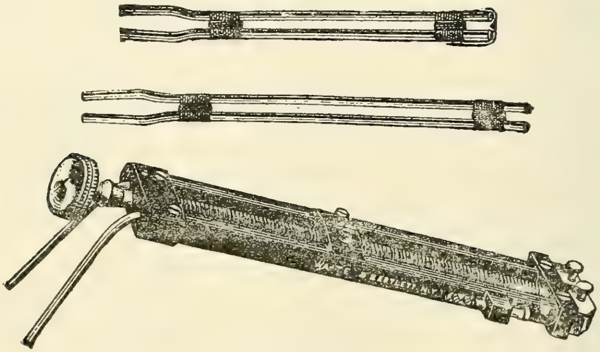


FIG. XXVI. Handle for Heavy Cautery Work.

is concerned. A large platinum wire, No. 22 Brown and Sharp's gauge, should be used. This is important, for a smaller one may break and thus delay the operation. The handle used should be so constructed that powerful traction may be made on it by the operator. The small ecraseur handles that may be procured from the stores are excellent for nose and throat work but are of little use for this purpose. Here we must have a handle on which power enough can be exerted to sever the tongue, if need be, without heat. The wire is allowed to heat just enough, and no more, to cut its way with constant traction on the loop. To do this, it need never be brought to a perceptible redness. The operator

should keep constant and strong traction on the loop; in fact, he should use it as a cold ecraseur, except that the traction employed should require a very small degree of heat to complete its work. It is this one point, the constant and strong traction, that should be changed in Mr. Bryant's operation, as on this the success of the operation, so far as its bloodless character is concerned, depends. The advantages derived from this method of operating over that of Mr. Bryant's are:

First: The tissues are rendered so tense by the traction that much less heat is required to sever them than when the wire is left loose, and the smaller the amount of heat employed the less the liability to hemorrhage.

Second: It is easier to maintain a more steady heat as the wire is constantly imbedded in the tissues; with the Bryant operation the wire cuts itself loose, the heat rises rapidly, and, if the operator is not continually on his guard, will rise to a white heat before he is aware of it.

Third: It combines all advantages of the cold ecraseur and the cautery. The walls of the blood-vessels are drawn tightly together, little clots form in them, and the glutino-fibrous exudation around the wire glues, as it were, the closed ends of these vessels together. With the Bryant operation we get none of these effects. To repeat his own expression, "the wire of the ecraseur being screwed home only as it becomes loose by cutting through the tissues." It is evident that in this case the ends of the vessels are not drawn together and no clots form in them. If, when the wire in cutting itself loose, it should cut into the side of a vessel that is not constricted, the blood will be sure to escape by the side of the wire; if the vessel is first constricted and circulation stopped, blood would not flow.

Fourth: This operation can be safely performed with ether, as the wire is continually imbedded in the tissues and need never come to a red heat, consequently there is no danger of the vapor of ether igniting.

Œsophageal Stricture.—That we may the more readily comprehend the indications for treatment of œsophageal stricture

by electrolysis, and the results which may be expected therefrom, we must divide the various kinds of stricture into four classes:

First: Fibrous stricture caused by some inflammatory process in the œsophagus itself or some neighboring tissue.

Second: Cicatricial stricture, which is either caused by swallowing some corrosive liquid, or is the result of the healing of some deep seated ulceration of the mucous membrane and submucous tissue.

Third: Cancerous stricture.

Fourth: Spasmodic stricture.

In examining a case of stricture of the œsophagus for electrical treatment, care should be taken to determine the nature of the stricture. That it is cancerous does not necessarily contraindicate electrical treatment for temporary effects, but, of course, there is no hope of saving the patient's life. One should be cautious in giving a prognosis regarding the permanency of the cure in œsophagal stricture if a large spasmodic element is present, unless the spasm is dependent upon a small fibrous stricture at the same place, or upon a fibrous stricture either above or below the spasmodic one, in which case, if the fibrous stricture is cured, it will generally relieve the other. Dubois de Sangeon, however, claims to have had excellent success in several cases of spasmodic stricture with electrolysis, and strongly recommends persistence in their treatment. He does state, however, that the treatment is not successful in those cases due to general or outside causes.

The diagnosis of true stricture of the œsophagus, can, as a rule, be easily made by careful examination. It differs from spasm in that it comes on gradually, taking months or even years before obstruction is complete. With spasm the obstruction is apt to be sudden in its onset and as suddenly disappears. It is intermittent. Antispasmodic remedies relieve it in its early stages. The passage of a bougie in a spasmodic stricture either meets with no obstruction, or, if it does, slight pressure for a moment causes the obstruction to give way. Such is not the case with fibrous or cicatricial strictures.

Paralysis and dilatation of the œsophagus may produce difficulty of swallowing and regurgitation the same as stricture, but the passing of a bougie determines the difference. The possibility of a tumor, either post-pharyngeal or thoracic, should be excluded by a proper examination of those parts. If the stricture is cancerous, blood will generally be found on the regurgitated food and will nearly always be found on the bougie when it is withdrawn, no matter how gently the examination has been made. The general symptoms of cancer are also present.

It is difficult to diagnose the difference between fibrous and cicatricial stricture with the bougie. The history of the case, however, will help in determining this point.

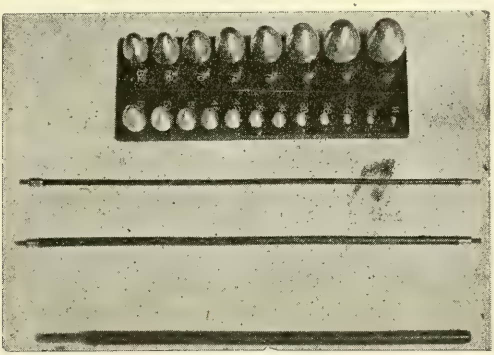


FIG. XXVII. Set of Œsophageal Electrodes.

After the nature of the stricture has been diagnosed, the case found to be amenable to treatment, and the size of the opening measured, an electrode one size larger than the caliber of the stricture should be selected and connected with the negative pole. We have a set of these electrodes made after ideas of our own, beginning with one four millimeters in diameter and increasing one millimeter with each bulb—the last one measuring 24 millimeters in diameter. These bulbs are made so that they can be screwed to a flexible stem eight inches in length, which, in turn, screws into a firm handle. The flexible part can be bent in any shape desired, while the

handle furnishes a strong grasp for the hand. On this handle are marks which indicate the number of inches or fractions thereof that the stricture is distant from the teeth. For a small sum each bulb can have a separate flexible stem soldered to it, but if care is exercised to have the bulb firmly screwed on there will be no danger of it coming off. These bulbs are a slight modification of the ordinary olive tip—being made in a perfect oval.

Sometimes in long standing cases, dilated pouches in which the bulb will lodge are found above the stricture. This difficulty may generally be avoided—if the dilatation is in the posterior wall, which is generally the case,—by shaping the stem of the instrument so that the bulb points forward, and consequently follows closely the anterior wall. This, however, is not always a safe procedure, as the sac may be located on the anterior wall, or even laterally. To overcome this difficulty, we have devised a set of bulbs with a director. This director is first introduced and the bulb threaded over it the same as in the case of an ordinary tunneled urethral sound. The first directors we had made were of celluloid, but these were not found altogether satisfactory. Of late we have been able to obtain whalebone films of sufficient length and they have proved all that could be desired. In introducing these electrodes great gentleness should be exercised, for rough handling will cause irritation. If there should be considerable resistance to the passing of an electrode, the same one should be used for the next treatment instead of going to one of larger caliber, but if it should pass through comparatively easy—say with from four to six milliamperes, and under gentle pressure, in from two to three minutes—one size larger may be selected for the next treatment. In some strictures, however, it will often be found that even two sizes larger can be used at a subsequent treatment.

Dilatation of the Œsophagus.—Besides the secondary sacculated dilatation of the œsophagus depending upon stricture, there are primary dilatations which may also be sacculated when the dilatation and elongation are sufficient for the tube to

double upon itself, but they are as a rule fusiform or cylindrical in character. With these primary dilatations, nothing much can be done, although successes have been reported. The method of treatment employed is to pass a bulb into the dilated portion, as one electrode, and to place the other in the form of a flexible hand electrode over the cervical region, giving a rather strong faradic current from the medium coil for twelve or fifteen minutes.

With the secondary pouches caused by stricture, much may be accomplished. The first indication is to remove the stricture, as this in itself removes the cause, and allows the muscular walls to recuperate, but the treatment recommended above—applying the faradic current to the dilated portion by means of a bulb—will assist very much.

Diseases of the Stomach.—Electricity has been successful in the treatment of chronic indigestion, dyspepsia, dilatation of the stomach, and paralysis and spasms of the stomach.

The introduction of an electrode into the stomach, through which water may be injected to be used as a medium of conduction, is altogether too severe for most patients, and has not, in our hands, been specially successful in any. It is quite probable that an application of galvanism over the region of the stomach, will tone up its walls when dilatation exists and improve its nutrition, but the degree in which it acts cannot be told with any great accuracy. It is claimed that the high frequency current applied directly over the stomach has a beneficial effect in chronic indigestion, but we have had no experience with it.

Dr. Baraduc says that the galvanization of the pneumogastrics made at the pharyngeal plexus in the neck (positive) and at the stomach (negative) immediately after eating, when digestion is slow and difficult, brings about the re-establishment of the digestive reflex, the hydrochlor-pepsic secreting reflex: it causes a characteristic eructation and starts digestion, provided the pneumogastric is not paralyzed or the tubular glands atrophied. Post-prandial pneumogastric galvanization is decidedly digestive. The positive poles are put between the

two branches of the sterno-cleido-mastoid and the negative is moved from the cardiac to the pyloric extremity of the stomach for from 10 to 30 minutes, according to the effect produced, the current not exceeding 4 or 5 ma. Take care to have no sudden breaks in the current. When the current is turned on the patient becomes quiet, the oppression and palpitations diminish and pulsation is lowered; he sleeps willingly; he breathes more easily, the gastric function, the hydrochlor-pepsic reflex is established, he eructates and feels much better. In gastralgia Dr. Baraduc has had some good results from the static breeze.

Larat strongly commends the use of the static spray and local faradization, or preferably the sinusoidal current, in the dyspepsias of cerebral origin such as follow excessive study or mental application, shock, violent emotions, sorrow, chagrin, etc. In the pre-menstrual gastric derangements its action is also very beneficial. In dyspepsia accompanied by true dilatation, treatment may require some time, but marked amelioration of symptoms is usually found in course of a few months. The faradic, or preferably the sinusoidal current, is connected with a large electrode placed over the region of the eight dorsal vertebra, the other electrode, of diameter about the size of a silver dollar, being placed over the hollow of the epigastrium and at the border of the gastric dilatation, when that exists, for five minutes. The electrode is then moved over the abdomen for two minutes, beginning at the right iliac fossa and following the ascending and transverse colon to the left side. The current should be of sufficient strength to cause contraction of the abdominal muscles and ought not to cause the least pain. When faradism is employed the coarse coil is chosen.

Gastralgia depending upon no organic condition, such as inflammation, and ulceration, may be as promptly relieved by passing a galvanic current through it, or perhaps a faradic current may prove better, as in neuralgia of other parts.

In organic diseases of the stomach, symptoms may be

relieved by the application of galvanism through that organ, but that is about all that may be expected at the present time.

Diseases of the Liver.—Organic and functional diseases of the liver may be treated successfully, so far as relieving the former and curing the latter, but the treatment differs in no essential from that given under constipation, to which the reader is referred. In icterus, excellent results have been reported from the use of the static breeze over the hepatic region.

Constipation.—The natural defecation of a healthy person depends, first, on a healthy digestion, and second, on a natural peristaltic movement together with the proper secretion of the intestinal glands.

Constipation is generally due to some error in diet, or to a lack of the proper regulation of the habits. In the early stage it may be easily corrected by a proper regulation of these two, and perhaps some medication. Unfortunately, patients do not always come under the wholesome influence of a physician so early in the case, but they go to a drug store and buy some sort of a cathartic. The poor, as a rule, buy cathartic pills, while the rich buy the expensive cathartic mineral waters. Which of these two do the more harm it is difficult to say, but the man who thinks that by using the expensive mineral waters he is doing himself no injury makes a mistake. Great relief is temporarily experienced by the use of these cathartics, and this induces the individual to continue them until they have completely disarranged the normal functions of the intestines, both large and small, so that massive doses have to be taken in order to produce the desired result. Regulation of diet and habits now have little effect, and medication fails to relieve the patient. At this critical juncture electricity can be depended upon to relieve, and permanently cure, 90 per cent. of the cases.

In treating a case with electricity there should always be two objects in view: first, to stimulate the secretion of the intestinal and digestive juices,—the bile, pancreatic juice and secretions of the intestinal tubules; second, to stimulate the secretion of the mucous membrane of the large intestines, and

to stimulate or regulate their peristaltic action. It is possible to produce regular movements of the bowels even in the most obstinate cases, by stimulating the large intestines alone, but it will be found that where no attention has been given to the first condition, the patient relapses after the treatment is discontinued, and also lacks all of that improvement in a general way which is characteristic of the treatment when given in its entirety. If electricity acted as a cathartic, it would be of no more use than any other purgative; but it does not so act, or if it should, it is the exception and not the rule, and is due to some peculiar condition of the patient at the time.

By stimulating the nerves and muscular tissue of an organ, we increase the nutrition of that organ, and when we increase the nutrition of any organ which contains glandular tissue, the activity and secretions of those glands are also increased. Taking these facts into consideration, the natural result of the treatment is easy to understand. When we come to the first consideration, that of increasing the secretions of the liver, the best results will be attained by placing a large, flat electrode about four by six inches over the right hypochondriac region, posterior, and a flat hand electrode over the right hypochondriac region, anterior, and giving a continuous current of from twenty to thirty milliamperes for fifteen minutes. The direction of the current is all important. The negative pole should be attached to the posterior, and the positive to the anterior, electrodes. Just why better results are attained by this direction of the current we cannot say, but clinical experience proves its superiority.

In stimulating the intestines, we should reverse the direction of the current, as we wish to concentrate the catelectrotonic effect of the negative pole on the intestines. To accomplish this, after reversing the current, the large flat electrode of the posterior surface should be removed to the sacral region. The flat hand electrode should then be given labile over the abdomen for a short time, say three minutes, and then stabile over the sigmoid flexure.

If it becomes necessary to introduce an electrode into the

rectum, the negative pole should always be attached to it. This, however, should never be done unless the rectal membrane is very dry, a condition such as is produced by a long continued use of rectal injections of water or various other substances, particularly if glycerine has been used for this purpose. One case of constipation which we failed to cure, was that of a theological student who had for a number of years used a small injection of glycerine daily, and the most obstinate cases we have ever seen were those which had previously used glycerine in the rectum.

An electrode by which the galvanic current can be carried into the rectum without harm, through the medium of water, thus preventing liability to any electrolytic effect, should be used. A description of such an electrode will be given at length in the section on Genito-Urinary Diseases under Spermatorrhœa and need not be repeated here.

The treatment should be given for twenty-five or thirty minutes and divided equally between the liver and the intestines. The strength of the current used will naturally vary with the sensitiveness of the patient; but one should always try to reach 20 ma., while it is unnecessary to go beyond 35 or 40 ma.

No one would venture to advise the faradic current in treating the liver, but it has been used largely to stimulate the intestines. While it may possess more muscular stimulating properties than the galvanic current, it is certainly inferior in all other respects to galvanism. The greatest stimulating effect obtained on the intestines is by using the galvano-faradic current or the sinusoidal current. Occasional alternation of the galvanic current while not being severe yet produces strong contractions of the intestines.

It is, however, probable, judging from its effect on voluntary muscles, that the sinusoidal current actually stimulates the intestines to contraction more than any other form of electrical manifestation.

There is one condition, and that is, a constricted or spasmodic sphincter of the anus which frustrates the best efforts.

This is the only condition, except the long continued use of glycerine or other injuections into the rectum, of which that can be said. Such a condition is sufficient to prevent a cure by this method. It is a rare complication, but it sometimes exists, in which case it is necessary to stretch the sphincter before a cure can be made.

Huhnerfauth recommends galvanization of the rectum as a purgative. The anode is introduced into the rectum and the cathode applied along the descending colon; 2 to 5 ma. are passed for from 2 to 5 minutes. No mention is made of the nature of the internal electrode, which he makes positive.

In beginning to treat a case of constipation with electricity, all medication in the form of laxatives or cathartics should be discontinued, with perhaps one exception. In some cases, where the secretions are particularly scanty, the stools will be very large and dry, and if they pass the sphincter they are liable to cause soreness, so that the next stool will not be allowed to pass on account of the spasms set up by this soreness which are beyond the control of the individual. Of course, it is most desirable to avoid such a condition and this may be done by giving, three times a day before meals, five to eight drops of hydrastis tincture in a glass of water. This does not act as a cathartic or even a laxative, but has decided action in softening the stools. It is never necessary to continue it but a few days, and it should be gradually discontinued.

The fæces are made up of refuse, and intestinal secretions. After one has taken cathartics which have forced large quantities of secretions from the intestinal glands, and then discontinued them, reaction takes place with a consequent reduction in the amount of secretion. The stools at first will therefore be very small. This will worry the patient, for generally he is one of those who think that a very large stool is necessary. As treatment goes on, however, and a healthy condition is established the stools will gradually increase in amount until they become normal.

Intestinal Obstruction.—It is generally conceded that the medical treatment of intestinal obstructions and occlusion is a

failure, and surgery has been freely resorted to. There are undoubtedly cases in which electrical treatment may be beneficial and a surgical operation be thereby avoided. A true case of intussusception might possibly be thus relieved, but that is very doubtful. A simple kink in the intestines or fæcal impaction would be more readily relieved by this treatment. Electrical treatment, if to be employed, should be resorted to early; if not successful after about three attempts in twenty-four hours, it is useless to continue it longer. The galvanic current should always be used. The muscular fibre of the intestines is slow in action in health, and especially so under these conditions, and the short currents of which the faradic is made up, do not act long enough to produce any great stimulation. This is particularly true if an intestinal muscle has been stretched, or if it has become paralyzed from shock; but the galvanic current acts upon it even in these conditions.

The method of treatment is to first place the patient in that position in which the largest amount of water may be injected into the intestines. The knee-chest position is probably the best, if the patient is in condition to bear it. A long gum rectal catheter, which can be found in almost any drug store, may be used for injecting the water. This should be most carefully done. If the patient feels he can not retain more, the injection should be stopped for a minute or two, when it will be found that more may be given. A short copper wire may be put down the opening of the catheter, to serve for an electrical connection, while the thumb is held firmly over the opening, to prevent the escape of the water. By this means we get a very large liquid conductor; not only does this stimulate the intestinal wall with which it comes in contact, but as the intestinal walls are excellent conductors themselves, the entire intestinal mass is brought under the influence of the current. The other pole should be in the form of a large clay pad, pressed tightly over the abdomen. There is no danger of electrolysis here. A very little salt added to the water injected will improve its conductivity. This should, however, be done

cautiously as a hypochloride is formed which in large quantities might act as an irritant.

The success of the treatment will depend upon the stimulation given to the walls of the intestines. It is best to start first with the positive pole internally, passing a current of from 40 to 50 ma. from three to four minutes, and then reducing the current to zero, quickly reverse the poles, increase the current again to 40 or 50 ma. and allow it to pass for five or six minutes; then reverse the current again the same way, always first reducing it to zero to avoid shock. After it has passed the required time in this direction, reverse again and allow the current to pass for five or six minutes more. If success is to be the reward, the patient will begin to have a desire to have something pass. If this occurs, the treatment should continue with reversals every five or six minutes until the desire becomes imperative. As soon as the electrode is withdrawn, water, flatus, and perhaps some stercorate matter will pass. If this occurs, the case may be considered cured, but unfortunately these results are not always attained. If a little flatus passes it is a good sign. The patient should be allowed to rest for a time, about four hours, before the second treatment is given and a third trial may be made four hours after that. If there are no signs of the breaking up of the obstruction after the third attempt, it will be useless to continue the treatment longer.

Beaudet, of Paris, has gathered statistics of fifty cases, with success in fifty per cent. In selecting cases for this treatment, we must depend largely upon judgment. The exact nature of the obstruction cannot well be determined. In many cases, when it is due to a contraction from old erosions, organic strictures, and intussusception, or pressure of tumors, the electrical treatment will probably be of no use, but if it is carefully given, it will do the patient no harm any more than a deep injection, and it is far more successful than the latter in stercorate obstruction and intestinal palsy.

Stricture of the Rectum. Stricture of the rectum is not an uncommon disease. It has been successfully treated by electro-

lysis. The method of application does not materially differ from that in the case of stricture of the œsophagus. The caliber should be carefully diagnosed, and an olive-tipped electrode one size larger selected. This, of course, is attached to the negative pole, while the positive should rest over the sacrum. Stronger currents may be used than are used in the urethra. Pressure is made sufficient to keep the electrode well in contact with the stricture. The electrode will finally slip through, and it should be withdrawn while the electricity is still on. Next time a size larger may be used.

We have given this treatment with success in cases that have resisted all other known remedies. One case of a chronic diarrhœa, accompanying an organic stricture of the rectum, that had baffled both physicians and surgeons in Europe and America, was successfully treated. After the twelfth treatment the diarrhœa ceased, the patient improved in health and is well to-day, two years after discontinuing treatment.

Tubercular Peritonitis.—Ausset and Bedard report two cases of tubercular peritonitis cured by X ray. Treatment of the second case commenced June 4th, 1899; eight minutes seance; tube 25 cm. from abdomen of child; treatment every other day; seance gradually lengthened and distance of tube shortened until 15 minutes and 15 cm. were reached. By June 25th, the abdominal circumference was diminished; at the end of July, the fluid had disappeared, and in spite of interruptions during vacations, the cure was complete.

Fissures of the Anus.—By means of the high frequency current Doumer and others have treated numerous cases of fissure of the anus with uniform success. The technic is as follows: The electrode is carefully introduced into the anus sufficiently deep to include the whole of the sphincter muscles. The violet sparks are then applied for from five to eight minutes. Usually improvement is rapid; the pain in the sphincter gradually diminishes, the fissures become cicatrized and spasms yield readily. In severe cases, several days elapse before a cure is complete.

SECTION FIVE.

Genito-Urinary.

Spermatorrhœa.—It should be understood that electricity is only a part of the general cycle, *i. e.*, surgical, medical, hygienic and general management of the treatment of spermatorrhœa. All are required and the physician who fails to study his patient and look after him in every particular, will not often be rewarded with success in treating a well established case. About the first use to which electricity is put in the treatment of spermatorrhœa is for the removal of a deep urethral sensitiveness which is almost sure to be present in the early or nocturnal pollution stage.

If the urethra is excessively sensitive, a sound should be introduced and at once withdrawn, but after the sensitiveness has disappeared to such a degree as to allow the sound to remain a minute or two without causing faintness or spasms, the galvanic current should be administered to the parts through it, that is, it should serve as the negative electrode. A flexible hand electrode is placed upon some convenient part of the body and the positive pole attached to it. This serves as the inactive electrode. A steel sound, as large as the urethra will take without producing undue dilatation, is introduced, the negative pole attached, and the current gradually raised to about two or three milliamperes, at which point it is allowed to pass for one or two minutes, and then as gradually reduced. The ordinary conical steel sound will answer the purpose, as it is not necessary to have any part of it insulated. This treatment is recommended, presupposing that the operator is skilled in the use of urethral instruments.

The theoretical electro-therapeutist may object to this, claiming that, as the positive pole, or anode, produces anelectrotonus, or a decrease of irritability, it is the one that should be used in the urethra, instead of the negative, or cathode, which produces catelectrotonus, or increased irritability. However, after considerable experience, we can affirm that the cathode is far more efficient in relieving a congested, irritable condition of the deep urethra than is the anode. The current used is weak, and the electronic effect is correspondingly small, and does not play an important part, while the electrolytic effect does. The slight alkalinity which is produced around the sound has a very beneficial effect on the congested, irritable state of the urethra, while the acid and chlorine set free at the anode seems more irritating than otherwise.

A rapid decrease of the sensitiveness of the urethra will occur after the electric current is used. This treatment may be given first three times a week; but, after the sensitiveness has abated somewhat, daily applications may be made. In cases of long standing, particularly those in the second or third stage, the sensitiveness all disappears except in a circumscribed spot. On closer examination it will be found that this spot marks the opening of the spermatic ducts into the urethra. In this case, a Newman sound should be introduced so that the uninsulated part, which is the bulb at the end, comes in contact with the sensitive spot, and a current of four or five milliamperes given for from one to one and a half minutes. This is not current enough to produce any electrolytic disintegration of tissue, but the alkalines set free are sufficient to bring about the desired result. We have, by this treatment, cured a case after the application of nitrate of silver had failed. The current has, also, another important action: it stimulates to contraction the muscles of the dilated ducts, which are always more or less paralyzed in the later stages, and thus prevents the constant escape of the semen. This treatment should not be given oftener than once or at most twice a week.

When there is evidence that discharges are the result of

paresis of the seminal ducts, true spermatorrhœa, if the urethral treatment does not give entire relief, applications of either galvanism or faradism should be made through the rectum. It is best to begin with a medium coil faradic current, and if, after treatment of two or three weeks, thrice weekly, there are no signs of improvement, galvanism should be resorted to. Of course the irritable condition should have entirely disappeared before the faradic current is used in the rectum, as its stimulating qualities are such as to render the condition more irritable, but in the paralytic stage there is no danger. If faradism is given, the ordinary rectal electrode may be used. This is introduced to a point just above the prostate; the other pole, attached to a flexible hand electrode of good dimensions, is placed well forward upon the perineum and a current of a strength that is easily bearable is given for from eight to ten minutes.

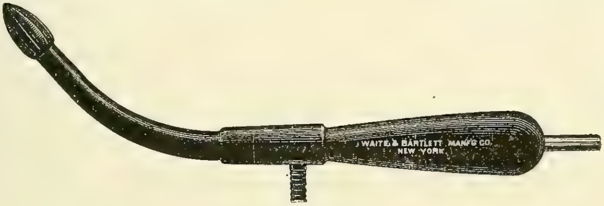


FIG. XXVIII.

It is unsafe to use a sufficient strength of current of galvanism in the rectum with such an electrode, as the electrolytic action of the current is liable to destroy tissue. For this purpose we have had constructed an electrode which obviates all this danger. It is represented in Fig. XXVIII. It is covered with hard rubber, which perfectly protects the metallic parts from coming in contact with the membrane. The end to be introduced has a small metal bulb inside the rubber sheath. In this sheath are narrow slits, and, as the sheath is much larger than the metal bulb it contains, the latter cannot come in contact with a fold of the mucous membrane, no matter how small that fold may be.

This electrode is used as follows: introduce the bulb well up

into the rectum (about two inches), attach a syringe to the projection seen at the lower surface of the instrument, and inject water, which is forced through the hollow tube and through the slits of the rubber bulb into the rectum. The patient will inform you when the rectum is full; and it is best not to inject too much, as it may be forced back by a spasmodic action of the intestine. The liquid acts as a conductor. The treatment given with this instrument possesses one great advantage; that is, the current acts upon the entire surface of the rectum, as far as the liquid has gone.

A current strength of ten milliamperes may be given two or three times a week, the negative pole being attached to the rectal electrode. It is even better to use this electrode with the faradic current; but this is not so absolutely essential as it is with the galvanic.

Robinson recommends a urethral faradic treatment for paresis of the seminal ducts. We do not believe it will often be required and when it is given it should be administered with great caution. A very light current should be given, only enough to produce a slight burning sensation, and this should be continued for not more than three or five minutes.

When we come to the spinal treatment, we must consider the stage of the disease. In the irritable or nocturnal pollution stage, a good-sized electrode—from three to five inches—should be placed over the lumbar region, and the positive pole attached as we wish to produce anelectrotonus or a state of decreased irritability in the lumbar spine. The negative pole should be applied to the perineum. The current should be gradually raised to its maximum of from eight to ten milliamperes, and after remaining there for three or four minutes, as gradually reduced to the zero point, care being taken not to interrupt the current, as in such a case the opposite effect will be produced. Treatment of this kind, given three times a week or oftener, will be found of service in allaying the irritability and stopping the nocturnal pollution.

If, however, we wish, instead of allaying the irritability to overcome a paresis, true spermatorrhœa, we reverse the

position of the poles; or what is better still, to draw sparks from the entire length of the spine especially from the lumbar portion and from the perineum.

No case of spermatorrhœa, either of nocturnal pollutions or true spermatorrhœa, has existed for any length of time without having a depressing effect to a greater or less degree on the general nervous system. This depression will of course be in proportion to the severity of the case, but the constitution of the patient will have much to do with it, and as spermatorrhœa is more liable to occur in those who are constitutionally weak in their nervous system, there is almost certain to be in cases of long standing, more or less neurasthenia, especially spinal neurasthenia, and this should receive appropriate treatment. However, as this has been given very fully in another section, it need not be repeated here.

Impotence.—In the early stage of irritable impotence—premature ejaculations—the patient will be very likely to suffer from the deep urethral sensitiveness which should be removed by the introduction of the steel sound together with the application of galvanisn, as described in the treatment of spermatorrhœa. In the more advanced stage of impotence there is likely to exist anæsthesia of the glands and integument of the penis.

The loss of peripheral sensitiveness is particularly noticeable to the electric current, either galvanic or faradic. If found to exist in a mild form, rubbing the penis vigorously with an ordinary sponge electrode attached to one pole of a faradic battery, while the other electrode is placed over the lumbar region, will suffice. If the anæsthesia is more severe, the wire brush electrode should be used in the same manner as the sponge, passing as strong a current as the patient can bear, which, of course, will depend upon the degree of anæsthesia present.

In those cases of paralytic impotence—absolute loss of erectile power—where the meatus is pale, which is an indication of the anæmic condition of the deep urethra; or, in cases of the irritable type, after all sensitiveness has passed away

and erections show no signs of returning, electrical treatment of the urethra will be of benefit.

The faradic current with the median coil, No. 32 wire, should be selected. One cord is attached to a flat hand-electrode and placed well up against the perineum; the other is attached to a full-sized steel sound which is inserted into the deep urethra. Some object to the urethral application of electricity, claiming there is danger of setting up an urethritis, but if the operator is at all skilled in the use of the steel sound and follows the directions given below, there will not be the slightest danger of urethritis following the treatment.

First: Use all the precautions in introducing the sound that would be required in the most sensitive urethra.

Second: Never use the current stronger than to produce a slight sensation underneath the perineal electrode. It is unsafe to be guided by the sensations produced within the urethra, for in many cases of paralytic impotence there is a loss of sensitiveness of the urethral membrane to the faradic current, and, consequently, the sensation produced is unreliable as a guide to the strength of the current. When there is no loss of urethral sensitiveness there will be a slight burning alongside the sound.

Third: The duration of the first treatment must not exceed one-half minute, and subsequent treatments must never be extended longer than three minutes.

Fouth: When first beginning treatment applications should not be made oftener than every third day; but later, if the patient bears it well, it may be given every day.

The general electrical treatment is very important in impotence.

First give a descending current along the spine—positive at nape of neck and negative on coccyx—of fifteen milliamperes for four minutes; then place the negative pole over the lumbar spine, and press the positive firmly against the under surface of the testicles and penis. Large-sized electrodes should be used, and a current of ten milliamperes given for four or five minutes longer. It may be well to alternate the

current a few times by means of a pole changer. Sometimes the faradic current has better effect when applied to the penis and testicles than the galvanic, but the best result will be attained by using the galvano-faradic (see general electrotherapeutics). The poles should be placed, so far as polarity is concerned, the same as given above for the galvanic.

The application of electricity to the testicle is very important in many cases of impotence, especially paralytic impotence, as well as for sterility due to atrophy or induration of the testicles. It is not an easy matter to administer electricity to the testicles in sufficient quantity to be of use. There are two methods, however, which we have employed, and which have given satisfaction. One is to cover the testicles with a layer

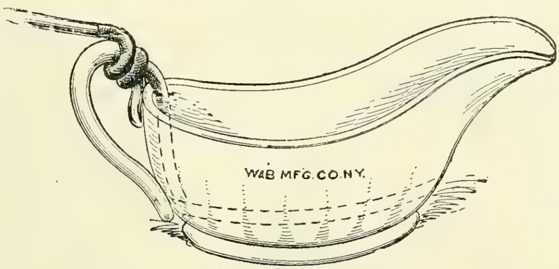


FIG. XXIX.

of absorbent cotton which has been saturated with a weak solution of salt water, so that all parts of it conduct readily; this is covered with a thin layer of lead, which is wrapped around it and has a rheophore connection. The other method is to take an ordinary oblong gravy dish—one of common earthenware is best, as the plainness of its outlines makes it more convenient than the fancy shape of the expensive ones. A copper plate connected with a wire, the other end of which has a rheophore attachment, is placed in the bottom of the dish and covered with a sheet of rubber or asbestos, so as to prevent the testicles from coming in direct contact with it (Fig. XXIX). The wire may be wound around the handle of the dish, to hold the copper plate in position. This dish is partially filled with a saline solution. With the patient stand-

ing, his body bent forward, his elbows resting on a table, so as to cause the testicles to swing a little forward, the dish is pressed up around them so that the solution comes well up above the testicles. Of the two methods, the latter will generally be found to be the more satisfactory.

In those cases where simple stimulation of the testicles is indicated, the faradic current will be most useful; but, in cases of atrophy, the galvanic is superior, although an occasional treatment with the faradic may be given with benefit.

In administering electricity to the testicles, place the positive pole on the lumbar region and the negative on the testicles. The duration of the treatment should be from three to eight minutes, and it may be given daily or every other day. The strength of the faradic current should be gauged by the feelings of the patient, but should never be very strong—not strong enough to produce any disagreeable sensations either during or after the treatment. From three to ten milliamperes of galvanism may be given. The treatment should never be crowded so as to produce a sickening feeling, which will surely occur if a high amperage is given.

This treatment, both for atrophy and induration of the testicles, should be continued for a long time—at least for three or four months, if recovery does not set in before.

The static wave current certainly gives promise of great benefit in impotence. We have very recently succeeded in invigorating both the sexual instinct and the power of erection in a man seventy years of age. The weakness seemed to be due to no other cause than old age. The testicle and penis were wrapped in tinfoil and the tin electrode wrapped around this. About a two inch spark was used. It will require a larger experience to give this treatment a definite field of action.

Dubois and others claim excellent results from galvanism in the treatment of orchitis. The positive pole is placed beneath the testicle, the negative along the cord and from 4 to 6 ma. are employed for from 2 to 5 minutes, according to the tolerance of the patient. By moistening the negative pole with a 20% solution of iodine, subsidence of the swelling is quickly brought

about, the pain diminishes and complete restoration is obtained after several treatments. This treatment should apply equally to epididymitis.

Aspermatism.—The electrical treatment is most important in neurotic aspermatism. At first a descending current of ten milliamperes should be given along the spine for three minutes. Then the positive electrode should be removed to the perineum and under the surface of the scrotum, and the negative given, both labile and stabile, over the lumbar spine for as many more minutes, using about the same strength of current. In addition to this treatment, the faradic brush, as recommended in impotence, should be given over the penis for three minutes, when anæsthesia exists. In those cases due to a lack of proper co-ordination or working of the motor cells of the spine controlling the ejaculation act, a steel sound should be introduced and the faradic current applied as given in impotence, but this treatment should not be given so long as there is any deep urethral inflammation remaining. Treatment may be given daily, and in severe cases daily treatments are required, but, in mild cases, every other day will suffice. We have seen cases recover after one week's treatment; but, if necessary, it should be persisted in for at least two or three months, before the case is pronounced hopeless.

Stricture of the Urethra.—There is no subject connected with electro-therapeutics which has had stronger advocates and more positive opponents than the electrical treatment of stricture of the urethra. It is claimed on the one hand, that all strictures may be successfully treated by this method, and with more permanent results than by any other; on the other hand, it is declared to be impossible to cure any kind of a stricture by this means. The subject has long been one of controversy, but until Dr. Robert Newman of New York first published his essay on this subject and gave to the world the more perfected instruments and improved technic, it could not be claimed that electricity held a permanent place in the treatment of urethral strictures. The very large number of cases on record cured by this method, and the numerous supporters

it has among the most prominent physicians of the world, now places it beyond controversy. A purely cicatricial stricture is not so easily relieved as those due to proliferation of cellular connective tissue elements, and a consequent proportionate increase in the thickness, density and inelasticity of the membrane. Where the stricture was immediately behind the fossa, within an inch from the meatus, we have not had the success that we have had when it was located in the deeper portions of the urethra. Why this is so, we do not attempt to explain. Some physicians of our acquaintance have had a similar experience, while others have not noticed any difference in the location, so far as the success of treatment is concerned.

The method of treatment is very simple. The calibre of the stricture should be carefully diagnosed together with the length of the narrowing of the canal. This may be done by

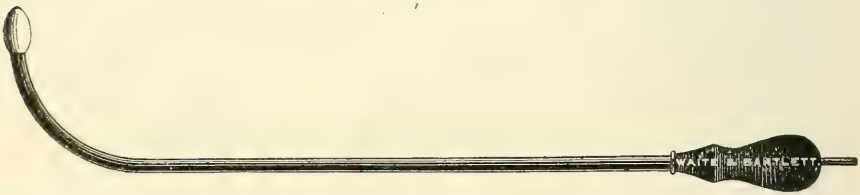


Fig. XXX.

using the ordinary bulbous bougie. The Newman electrode is a very good instrument for this purpose. After the caliber of the stricture has been diagnosed, one of a size larger should be chosen if the stricture is of the annular or tortuous type. If, however, it is of the linear type, two sizes larger of the French scale may be selected. The inactive electrode after being well moistened in warm water, is placed on some convenient part of the body and allowed to remain there for a minute or two, so as to decrease the resistance of the skin before the electrode is introduced. The bulbous electrode, Fig. XXX, after being made thoroughly aseptic, and lubricated with a little vaseline, is introduced before the current is turned on. Vaseline is generally prohibited on account of its non-conductivity, but liquid vaseline is probably rubbed off from the bulb before it reaches the stricture. At any rate, the resistance it offers is

so very slight that its use is not debarred. After the bulb is engaged in the stricture, the current is turned on, generally reaching about four ma., never above six and seldom below three. Four ma. will be found a very equable quantity. The stricture is kept firmly engaged by slight pressure upon the instrument. After one to three or four minutes, according to the nature of the stricture, the instrument will slip through with a slight jump, when it should be gradually withdrawn, thus engaging the posterior surfaces of the stricture.

Great care should be exercised in those strictures in the deep urethra which involve the membranous portion. The membranous portion is surrounded by a group of muscles known as the transverso-urethra, the so-called "cut-off" muscle which is one of the most spasmodic and irritable muscles in the body. So irritable is it, that the mere presence of a bougie in the

FIG. XXXI. Electrode for Treating the Membranous Urethra.

bulbous portion of the urethra will at times cause spasmodic contractions. When we have added to this the irritation of an electric current, which seems to have a particularly irritating effect on this muscle, it will be readily understood how a stricture in this locality is so complicated by spasm that it is often impossible to pass an electrode through it. In ten cases of stricture, occupying a space of nearly one inch, lying about equal distance on either side of the bulbo-membranous juncture, we were able to introduce a steel sound of certain size easily. In only three of these cases was it in any way possible to introduce an electrode of equal diameter when the current was turned on ever so slightly. Seven cases or seventy per cent. would not admit the electrode.

We wish here to call attention to an instrument by which it is possible to obviate this spasm, and thus to treat a case of

stricture successfully with electricity at this point. This instrument has a conical steel point separated from the bulb back of it by a thin piece of ivory. This is for insulating purposes, the bulb only carrying the electric current. The remainder of the instrument is hard rubber. The bulb is generally one size, American scale, larger than the conical steel point.

First, the size of the stricture is diagnosed, and an electrode is selected in which the projecting point corresponds to the size of the caliber, thus allowing the point to pass until the bulb is brought firmly against the stricture. After it is in position, the current is turned on, and not before. If a spasm of the "cut-off" muscle takes place, the muscle contracts on the projecting steel point, which it firmly grasps for a moment or two and then relaxes. This may occur two or three times, but not as a rule. All that is necessary is to hold the instru-

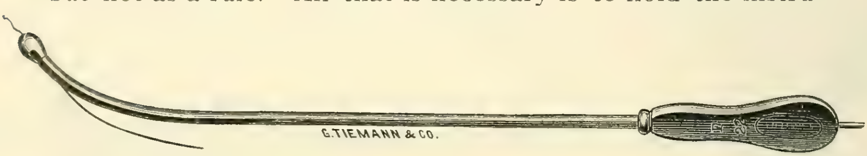


FIG. XXXII. Newman Electrode with Director.

ment in position, with slight pressure against the stricture. The spasm will soon cease, and the full effects of the bulb in passing the stricture will be attained. This instrument is more easily introduced than the ordinary Newman electrode. We also get the quieting, soothing effect of the cold steel point, and the curative effects are just as certain. If, however, this instrument is not used, the bulb should always be introduced over a director.

In organic stricture it will not be difficult to introduce a filiform; but when no organic stricture is present, it is very difficult to introduce one. This is, no doubt, owing to the fact that the organic stricture gradually narrows the canal, thus making a smooth guide into the small opening. In a case which we have recently treated, and which has been the rounds of many surgeons and electricians, it was found im-

possible to introduce a bulbous electrode even over a filiform, but with the ordinary tunnel sound the introduction was comparatively easy. The stricture was of the tortuous type, involving at least an inch, beginning some distance in front of the membranous urethra and extending back into it. Very marked success attended the treatment, which was done wholly by introducing an ordinary tunneled steel sound over a filiform. It is a question whether the best results may not even be attained in some cases, especially those very severe and tortuous, by using an uninsulated steel sound instead of the bulb. The former are certainly much easier of introduction, do not require the skill of manipulation, and do not produce the irritating spasmodic effect that the bulb does.

It may be argued that as the urethra is a good conductor of electricity, it is impossible to concentrate much current upon the stricture. As an answer to this, it can be said that as the contact is much firmer at the point of the constriction, the resistance is less, and consequently the effect correspondingly greater at that point. Furthermore, it is not the electro-caustic effect which we wish to obtain in the treatment of strictures, but rather the electro-chemical or the so-called catalytic effect. Whether we attain this best by passing the larger quantity of current through the organ instead of passing a smaller amount through the one point, as the catalytic effect is larger in proportion to the amount of current passed, is not easy to say. There is less danger of passing eight milliamperes through an instrument which has no insulation, than there is to concentrate four milliamperes on a small point. We also get in addition to this, the absorptive effect of the conical steel sound. So satisfactory has this form of treatment been, that we do not use the bulbous urethral electrode now nearly so often as in years past.

Linear Electrolysis.—Fort, of Paris, some years ago instituted a method of treating urethral stricture which he called linear electrolysis. This treatment combines the principle of cutting a stricture and electrolysis. In fact, the stricture is severed in a manner similar to the cutting operation, but the severing is

done by electrolysis instead of by the knife. This method possesses the advantage that the electrolytic destruction of tissue by the negative pole does not contract; at the same time, the severing of the stricture by electrolysis prevents the edges of the wound from healing together. The method of operating is simple in theory, but requires great care and skill in practice. The electrode seen in Fig. XXXIII is insulated in all its parts except the metal projection seen near its distal end. It is this wedge-shaped metal which makes its way through the stricture by electrolysis. This instrument should never be used except over a filiform director. It is of small diameter and to use the pressure necessary to procure the contact in severing the stricture without unduly prolonging the treatment, makes it dangerous except over a director. The

FIG. XXXIII.

positive pole is placed over the abdomen or lumbar region, while the negative is attached to the urethral electrode. A filiform is first introduced through the stricture and the electrode threaded over it and pressed down until the exposed metal wedge-shaped loop is brought firmly against the upper border of the stricture. The current is then gradually turned on.

The patient's feelings should always be taken as a guide to an extent in the dosage. Eight or ten milliamperes may generally be given without harm and it is better not to go beyond that point. Firm pressure is made on the instrument until it slips through, when it is gradually withdrawn so as to get an electrolytic effect on the posterior surface of the stricture. Conical steel sounds of increasing dimensions are introduced

every other day for two weeks and after that at much longer intervals. There is no gainsaying that this treatment of urethral stricture is very successful; but that it is devoid of all danger from complications and inflammations, as claimed by its author, even in his own hands, is however true.

Hydrocele.—The electrical treatment of hydrocele is the same as that of any other cystic tumor. We do not advocate it, for while it disperses the effusion within a few hours, the sac soon refills and the results are so seldom permanent that it is not worth the while. A platinum needle, to which is attached the positive pole, insulated to near the point is thrust into the sac, while the negative rests over the abdomen. Care should be exercised to prevent the exposed parts of the needle from coming in contact with the testicles or spermatic cord. A current of 15 milliamperes may be given for fifteen minutes. There will be an increased flow of urine for the next twelve hours; and the scrotum will return to a normal condition.

Incontinence of Urine.—So varied are the causes of urinary incontinence, and so frequently is the cause wrapped in obscurity, that no very definite idea regarding the results to be obtained from electrical treatment can be given. Generally speaking, the best results will be attained in those cases which are the result of nervous depression, or of paresis of the sphincter. In those cases where the paresis is due to overstretching from operative procedures electricity is of but little avail. If the muscle responds to the electric current, when that is first applied, it will soon lose all power of contraction and no amount of current can again stimulate it until it has had some hours to regain its contractile power. This is also true of the sphincter ani.

The treatment in purely local conditions should be local and when the cause is due to a general nervous depression, it should be both local and general.

The local treatment should consist of introducing a sound into the bladder. Better still, an insulated electrode with an exposed tip should be used and introduced to the point of contact with the sphincter, the other electrode being held firmly

just above the pubes; a faradic current should be given of sufficient strength to produce the slightest pain, but should not be given for more than five or six minutes. With children it is always best to try a purely external treatment—one electrode over the perineum and the other point above the pubes. If this should not prove helpful after six or seven attempts, the internal treatment may be resorted to. The general treatment may consist of a descending galvanic current along the spine, or of general faradization. If one possesses a static machine it is best to give the static breeze with a few sparks drawn from the spine, especially the lumbar portion.

The electric bath has given excellent results in incontinence of urine even in apparently incurable cases of long standing. It is best to give the treatment in the form of the sitz bath, 95% F., preferably with the sinusoidal current. Treatment should consume from 3 to 5 minutes and be repeated daily until the patient is relieved.

Gonorrhœa.—Metallic electrolysis has been recommended for chronic gonorrhœa; that it will stop a chronic gonorrhœal discharge there is no doubt, but the treatment is recommended on the supposition that no contraction will result from the use of the metallic electrolysis, a theory, strongly advocated by its promoters. This, we are satisfied, is a mistake and we believe that very severe contraction sometimes occurs after its use. We do not therefore recommend it.

Doumer claims good results in the treatment of gonorrhœa from high frequency currents. The current is carried to an instrument inserted into the canal or to a glass tube electrode located on the perinæum. Excitation has diminished, nocturnal erections have disappeared, edema has decreased (at the end of the 3rd or 4th seance), and, while the discharge keeps up for some time, he has seen a cure in ten or twelve days. In complications such as epididymitis and prostatitis a "marvellous" result is obtained. Generally they yield to a single application; improvement begins at the end of three or four minutes, and next day there is no pain at all.

Diseases of the Prostate Gland. Electricity has long been used

in diseases of the prostate gland, but the fact that the procedures have been constantly changing, new methods taking the place of old ones, is proof that all which has been claimed for it has not stood the test of a larger experience. There are, however, some points well established in the treatment of prostatic diseases by electricity.

Atrophy of the Prostate.—When we come to consider that the prostate is principally a muscle,—the glandular portion occupying only an insignificant part,—and that this muscular tissue is in structure similar to the muscular tissue of the uterus, we might,—considering the number of cases of atrophy of the uterus improved by the use of electricity,—conclude that benefit would result in a similar condition in the prostate, providing, of course, that the cause of the atrophy is removed.

We once treated a case of atrophy of the prostate in a patient, about 40 years of age, who had stone in the bladder which had been crushed by a lithotrite. Some time before the operation he noticed, in having sexual intercourse, that the semen would not come out in jets, as it had formerly done, but would dribble out and continue after he had withdrawn. When after the operation with the lithotrite it was found that this condition did not improve, as it was thought it would, the diagnosis of atrophy of the prostate was made and the patient sent to us for electrical treatment. He received three treatments a week, varying from ten to fifteen minutes' duration. The faradic current was used. One electrode was introduced into the rectum and carried up to the prostate, the other, a flexible hand electrode, was pressed well forward on the perinæum. The patient showed signs of improvement after the second week's treatment, and in nine weeks he had recovered to such an extent that the semen was all ejected before the withdrawal. He considered himself cured and discontinued treatment.

Hypertrophy of the Prostate.—We do not believe that any form of treatment will be of avail for the radical cure of an enlarged prostate, except the Bottini operation, which is given in the

next section, and which is a cautery operation, but we do believe, that electricity can be used to advantage in certain conditions arising from prostatic enlargement.

The treatment is generally best given with the faradic current, but the galvanic may be used. It is always better to begin with the faradic current; if that should not prove successful, try the galvanic. Great care should be exercised when the galvanic is used, and if any symptoms occur which indicate that the treatment is producing irritation, it should be discontinued until all signs of the irritation have disappeared. We formerly used an ordinary bulbous rectal electrode, but of late, we have employed the electrode which is described earlier in this section in spermatorrhœa, where water is used as the conducting medium. This is covered with hard rubber, which perfectly protects the metallic parts from coming in contact with the membrane.

The electrode is used as follows: Introduce the bulb well up into the rectum—about two inches—attach syringe to the projection seen at the lower surface of the instrument, and inject water, which is forced through the hollow tube and through the slits of the bulb into the rectum.

The other electrode of large size is first placed over the perinæum, and afterward over the hypogastric region. The whole treatment should last from eight to twelve minutes. The strength of the current, when the faradic is used, should be governed by the feelings of the patient. Care should be exercised never to cause distress; a slight bearing down in the rectum is sufficient, and it is just as well even to stop short of that sensation. If the galvanic current is employed, from five to ten milliamperes may be passed for as many minutes. Treatments may be given more frequently with the faradic current than when the galvanic is used. Ordinarily from one to three treatments a week will be sufficient.

In order to understand the conditions which we are to relieve by this treatment, it is necessary to look at the pathology of the disease. When we bear in mind that the blood returning from the vesical veins must pass through the plexus

surrounding the prostate, on its return to the general circulation, we can easily see how any enlargement of that organ is liable to obstruct the venous circulation and thus cause a venous congestion of the bladder-walls and membrane.

This venous congestion, together with the obstruction of the free flow of urine, thus putting greater labor upon the bladder-wall, at first causes slight hypertrophy of the muscular fibres of that organ. This hypertrophy, however, never entirely compensates for the obstruction, and soon the walls of the bladder are in a state of atrophy. As a consequence, mucus is thrown off, which makes the obstruction still more complete; finally, the bladder is incapable of completely emptying itself, and retention soon becomes a marked symptom.

Now, the treatment which we have given, if administered in the early stages, while it does not remove the enlarged prostate, stimulates the walls of the veins, improving the circulation and removing the venous congestion of the bladder. It also stimulates the atonic bladder-walls, and helps to overcome to a degree the obstruction, thus reducing the residual urine and lessening the liability to general cystitis. We have seen this treatment alone, in the early years of an hypertrophied prostate, reduce the mucus so that it was only noticeable by carefully looking for it, when before the treatment, it left deposits covering the entire bottom of a urinal, and the frequency of urination was decreased from one hour to three hours.

A case which came in our hands some time ago illustrates the benefit that may be derived from this treatment. A gentleman, 63 years of age, had suffered from hypertrophy of the prostate for three years; that is, he had first consulted a physician three years previous, but had suffered from a frequent desire to urinate some time before, although no date of the beginning could be given by him. During his three years of treatment, before he consulted us, he had taken various medicines internally, had faithfully washed out the bladder with borax water once a day and had also drawn his urine once a day besides. When we first saw him he was urinating on an

average of once in an hour and a half. The residual urine was from one to one and a half ounces and contained considerable mucus. The amount of enlargement was not great. He had discontinued internal medication for some time, and as we were desirous of not changing his treatment so far as medicine was concerned, so as to be able to judge what benefit had been derived from electricity, we continued with the borax-water wash. Treatments were given with the galvanic current every other day for three weeks, and twice a week for six weeks. At the end of the tenth week the mucus had decreased 75 per cent., the intervals of urination increased to four or five hours, and the residual urine amounted only to from one to two drachms. The patient greatly improved in general health. After the tenth week he was treated once in three or four weeks with the faradic current. Of course, when the posterior median hypertrophy is great, neither electricity or anything else will cause the base of the bladder to contract sufficiently to empty it entirely, but electricity helps.

Another very annoying condition which this treatment will generally relieve, either wholly or partially, is the rectal symptoms. These are of large variety and are mostly reflex.

Larat claims much success in the treatment of hypertrophy of the prostate gland by the employment of the sinusoidal current. The bulb electrode—properly insulated excepting at the bulb—is introduced into the rectum and brought in contact with the prostate gland. A pad electrode is then placed over the abdomen beneath the pubes and the current turned on and pushed to the point of tolerance of the patient. The treatment should consume from five to eight minutes. The advantages claimed for this method are its simplicity, the absence of pain and its general beneficial action. Dysuria is speedily diminished and in many cases, after a few seances, micturition becomes almost normal.

Congestion of the Prostate.—Although the prostate is, when in its normal condition, a very patient organ, it is, when in a state of congestion, one of the most irritable organs of the body. Galvanism applied in any way is very liable to aggra-

vate the symptoms of a patient suffering from an active congestion; but faradism given in the manner described under hypertrophy, particularly if the secondary coil is made of a long, thin wire, will almost invariably relieve the distress, temporarily when the congestion is of a chronic nature and permanently when it is of short duration.

We have, however, seen one case where the deposit thrown out by an inflammation was absorbed, and the symptoms accompanying a chronic congestion relieved by the galvanic current. The patient had been treated for stricture. Sounds had been introduced by a physician who evidently did not understand his business, for when the sound became obstructed in the deep urethra, he forced it past the obstruction, using considerable strength to do it and causing great pain to the patient. The next day an inflammation set in in the prostate but subsided in ten days without the formation of an abscess. Three weeks after this, an examination by the rectum revealed a hard, unyielding mass surrounding the prostate, of a fibrous material, thrown out during the stage of active inflammation. The prostate was only slightly sensitive on pressure. The patient felt a fullness and distress in the perinæum but no actual pain, and frequent desire to urinate. He also had a feeling as if he must have a movement of the bowels continually, but was unable to have a movement without an enema. There seemed to be a total inaction of the rectum.

A small, flat, rectal electrode, which was first covered with absorbent cotton and then all covered with a tight-fitting piece of chamois, was introduced. This was before we used the water electrode previously described. The other electrode was placed on the perinæum and a current of ten milliamperes passed for five minutes. This treatment was given three times a week for two weeks and once a week for three weeks. During the treatment the deposit disappeared so that the cellular tissue became soft and yielding to the feel, the frequent desire to urinate disappeared and the rectum resumed its normal function.

Dr. A. Freudenberg recommends electro-massage by means

of the "electric finger" in cases of prostatic disease. The technic is similar to that of the faradic hand in cases of neuralgia. On pole of the faradic current is attached by means of a large electrode to the hypogastrium of the patient, the other to the wrist of the operator. In order to avoid irritation of the buttocks, rectum, sphincter, etc., the hand of the physician is encased in a rubber glove, the extremity of its index finger being cut so that the finger may be protruded. The finger is then inserted into the rectum and the prostate may be massêd and faradized at the same time. Mild currents only should be employed, in order to avoid pain. This method would also be applicable in cases of seminal vesiculitis (speramato-cystitis) and we believe might be of benefit in true spermatorrhœa.

Follicular Prostatitis.—There is one more condition which we wish to mention, and that is follicular prostatis, commonly known as prostatorrhœa. A case has recently come under our care which presented the following history. Two years previous he had an attack of gonorrhœa, with symptoms indicating a congestion of the prostate, but which subsided after three days' perfect rest in a recumbent position. After the gonorrhœal inflammation disappeared there remained a slight muco-purulent discharge, and from that time, until we saw him he had been treated for gleet, stricture and spermatorrhœa, which, however, seemed to increase the discharge instead of relieving it. The only inconvenience he suffered was a slight irritation of the vesical neck. He would occasionally notice a slight discharge in the morning and also at other times, but he noticed it principally after straining at stool. A microscopic examination of the discharge showed that it contained fatty debris, leucocytes and some prostatic concretion. The case was diagnosed as prostatorrhœa.

A large-sized steel sound, No. 17, American, which completely filled the urethra, was insulated with rubber shellac to within two inches of the end. This was introduced so that the insulated part came in contact with the prostatic urethra. This sound was attached to the negative pole of a galvanic

battery, the positive being placed above the pubes. Four milliamperes were passed for three minutes. This treatment was repeated every ten days until five treatments were given. At this time the vesical irritation had disappeared and the drop in the morning was no longer noticeable, but occasionally a very slight drop, although very much less than before the treatment was given, could be seen after straining at stool. The patient now left the city, and, of course, treatment was discontinued. Whether more treatments would have entirely eradicated the trouble, cannot of course be told, but it is fair to suppose that they might.

SECTION SIX.

The Treatment of Hypertrophy of the Prostate Gland by the Galvano-Caustic Method, After Bottini.*

Introduction.—Bottini's operation is a method of surgical interference, electricity being only the means through which the cautery of the instrument may be heated, in a suitable manner, after its introduction into the bladder. If later on the proper glow of the cautery can be obtained through some other method as suitable or even more suitable than electricity, the operation would remain the same, in all other respects, as heretofore. This trite remark, which applies to the whole field of galvano-cautery, is especially opportune to the operation we are about to discuss. From it we can deduce, that the operation should be undertaken only by such as possess the necessary surgical training and skill, with special reference to urological manipulations. Those who possess these qualifications, especially if they are also fully conversant with cystoscopy and have made a careful and minute study of the Bottini operation, have every prospect for achieving good, yea, brilliant results; results which will constantly improve with increasing practice and experience.

Possession of merely a knowledge of general electro-therapeutics, however, does not suffice. Those who perform this

---

* This section is written by Dr. Albert Freudenberg, of Berlin, Germany.

operation backed by their electro-therapeutic knowledge and the possession of the necessary instruments only, will—even if by chance they may have surprising success—frequently and probably in the majority of cases have failures and mishaps which will prove equally harmful to the patient, the operation, and themselves. I am loath to publish the following description of Bottini's operation in this volume, devoted to electro-therapeutics, in which the latter is so extensively and broadly treated, without the foregoing preliminary remarks.

History of the Operation.—The radical treatment for hypertrophy of the prostate gland by means of the galvano-cautery *per vias naturales* was first performed and described by Bottini in 1874. Almost a quarter century elapsed, however, before the operation became generally known and was extensively accepted. It may be said, that the operation was first practiced on a larger scale since the year 1897. Possibly the author of these lines may claim the credit, without appearing presumptuous, of having assisted in no small way, by means of his publications at that time and later on, as well as his improvement of the armamentarium, in introducing this operation into practice.

The Armamentarium.—The armamentarium for the operation, aside from the electrical supply, was primarily composed of two different instruments, the cauterisator prostatæ and the incisor prostatæ. In the make lastly described by Bottini (manufacture of Camposteano, Milan), they appear as instruments having the form of a catheter of middle size, with a short beak turned almost at right angles. In the original shape the beak had the well-known angular bend of the Mercier instrument. The cauterisator, Fig. XXXIV, has close to the beak, resting upon a small china plate, a piece of platinum 2-2½ c.m. in length which the electric current is to heat. The incisor, Fig. XXXV, of which Mercier's "Inciseur" may be designated as the predecessor, consists, similar to the lithotrite, of a male and female arm; the male carries as a beak a platinum knife averaging 1.2 c.m. in height, which is extruded from the recesses of the female beak by the turn-

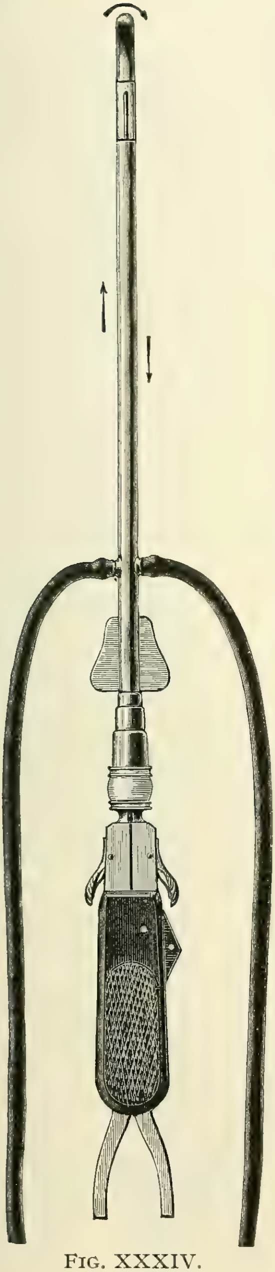


FIG. XXXIV.

ing of a wheel, located at the other extremity, which controls an archimedic screw. A scale attached to the extremity of the shaft accurately permits registering the distance the knife is traveling even unto millimeters.

Both instruments also have on the shaft small afferent and efferent tubes used as a cooling apparatus, by means of which through the inflow and outflow of water propelled through an irrigator, constant circulation to and from the point of the instrument is maintained. This improvement was adopted in 1882 and obviates unintentional burning of the urethra and bladder through heating of the whole instrument, which would otherwise occur. The action of the cautery is properly a galvano-caustic destruction, that of the incisor a galvano-caustic splitting, of the portions of the prostate gland interfering with the flow of the urine. The former instrument although originally preferred by Bottini, is at present only employed in the primary stage of prostatic hypertrophy; the typical procedure is the application of the incisor, and the following description of the technic of the operation, therefore, has reference to this method. On the other hand the cautery still has a certain sphere of application which must be carefully elaborated, in cases of spermatorrhœa, incontinence of urine, chronic prostatitis, etc.

In the year 1897, based on experience obtained with the Bottini instruments, I had various modifications made in the incisor. The modifications

refer to its shape and handiness, its electro-technical construction and lastly the feasibility of of safe sterilization.

The Freudenberg incisor, Fig. XXXVI, has, instead of the thin handle of the Bottini incisor, a stout, cylindrical, grooved handle which may be strongly grasped with the whole hand, not unlike the lithotrite. The appliance for cooling Fig. XXXVI *K*. does not commence beyond the handle, but this side of it, obviating the incalescence of same so often experienced with the Bottini instrument. The niche of the female beak is somewhat broadened, the knife being composed of platino-iridium instead of platinum. The conduction of the current to the knife inside of the hull of the male shaft is not accomplished by means of two thin wires, but by means of a single wire of about twice the volume of the thin wires, while the return conduction takes place via the hull proper of the male shaft. Furthermore, in consequence of the close contact with the canula, an electro-technical improvement is obtained which at the same time also provides increased firmness to the knife riveted on the one side to the inflexible hull. The connection of the instrument with the single wires, made up of the combined conduction wires, is accomplished by means of a peg-like protrusion corresponding to the axis of the instrument which receives the two poles in a concentric arrangement, and upon which the equally concentric cable contact is fastened. Fig. XXXVI *C*. The cable contact has attached a small contact screw which permits of the connecting or the shutting off of the current. Fig. XXXVI *C. S*.

The main superiority of the Freudenburg incisor, however, is in the fact, that by means of the use of a special putty which is water and heat proof, employed in the tightening and insulation of the instrument, same may not only be placed in the customary antiseptic solutions, but may also, like other surgical instruments, be sterilized in toto by boiling.[1]

---

[1] The instrument had best be boiled with the two tubes for the water-cooling apparatus attached. If, as I prefer it, the instrument is left dry, after removal from the boiling water, soda had better be omitted from the sterilizing fluid, as the same is deposited on the instrument and especially on the

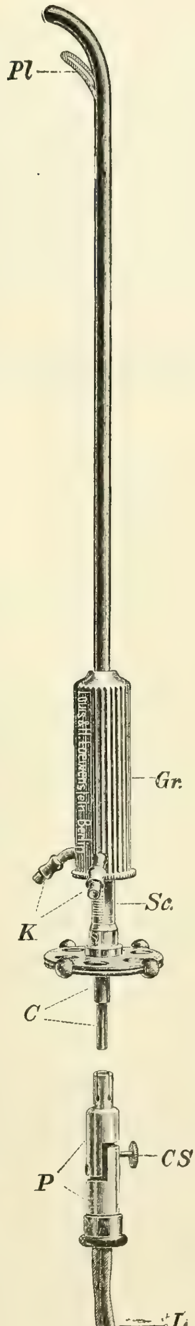


FIG. XXXV. FIG. XXXVI.

Incisor:

Pl—platinum iridum knife.

K—afferent and efferent tubes of the cooling apparatus.

Sc—scale.

Gr—handle.

C—contact pole.

Cable-contact.

P—pole of contact.

CS—contact screw.

L—conduction wire.

Later on (1899) I also modified the cautery on the same principle, Fig. XXXVII. A modification introduced by the well-known instrument firm of Hirschmann, Berlin, consisting of a rack-gear in place of the wheel which controlled the sciew, Fig. XXXVIII,—frequently erroneously called "Lohnstein's" modification—needs merely to be mentioned.

To sterilize the cautery, the peripheral portion of the instrument must be permitted to project from the fluid, as the

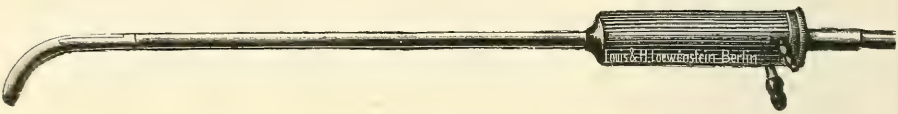


FIG. XXXVII.

cylinder at that end being composed of fibre, will not stand boiling. The instrument otherwise, in my opinion, shows no improvement.

A distinct deterioration, in my judgment, is the incisor recently mentioned by Schlagintweit (manufactured by Heynemann,

---

screw, after evaporation of the water, thus producing heavy action of the screw. In order to permit exclusion of the soda, instruments have been constructed for sometime past according to my directions, first by Herr R. Kiss, and at present by the firm of L. & H. Löwenstein, of Berlin, in which no iron of any kind is used in their manufacture. The screw is composed of phosphor-bronze, thus preventing rusting of same in ordinary water. I would like to add at this place, that the instrnment is best cleaned by holding it under a strong spray of water immediately after use and then dipping it into absolute alcohol or rinsing it with alcohol. The alcohol removes the moisture and after its evaporation the instrument is completely dry.

In case blood or any other foreign matter has become dry and fast to the instrument so that the spray of the water faucet cannot comp'etely remove it, the instrument is first boiled in a solution of soda and then treated as described above. Particles of slough which may remain adherent to the knife will be removed by heating same to a glow by means of the electric current. Specimens of my instruments which the firm of Jetter & Scherer, Tuttlingen, and their branch house, Kny, Scherer & Co., New York, manufactured and which were submitted to me in 1898 for judgment, contained several small defects to which the manufacturers' attention was called. Whether these defects have, in the meantime, been corrected, I do not know, as I have not since seen specimens of same. W. Meyer praises the instruments.

Leipzig), Fig. XXXIX. In this instrument the movement of the knife through the screw is replaced by a simple pull by means of the right index finger inserted in a ring, while the right hand encompasses the shaft similar to the grasp of a pistol. This instrument renders feasible the use of only the right hand for the manipulation of the instrument, so that the left index finger of the operator may be inserted and used in the rectum during the incision. If the latter is especially desired, it can be accomplished just as well by instructing an assistant to turn the wheel of one of my instruments. In discussing the technic later on, we will, however, be able to show that the method of having one finger in the rectum during the incision is to be strictly condemned.

FIG. XXXVIII.

That the substitution for the safe, uniform and controllably slow action of the knife through the governing wheel, for the simple pull of the index finger is a step backward will be readily perceived, especially,—as we will explain later on,—when one reflects how exceedingly important it is to perform the cut as slowly as possible. The prostatic incisor of Wossidlo combined with the cystoscope, also that of A. Freudenberg-Bierhoff will be mentioned later on.

The Electrical Supply.—The question of a suitable supply of electricity for the operation can first be considered solved by the introduction of accumulators into medical practice, for the batteries composed of cells of various construction, as used by Bottini, have given but imperfect results. It matters not which

accumulators are chosen, so long as they are sufficiently powerful, *i. e.*, are able with four volts, to furnish from fifty to sixty amperes. It is particularly desirable to have the accumulator transportable, absolutely essential, in my opinion, that same be provided with an ammeter. Only with the ammeter as introduced by me in the technic of the Bottini operation, can the operation be performed with ease of mind and safety. With its assistance, the strength of the current, circulating through the instrument, and from it the intensity of the glow of the knife, can be accurately determined. Without it, one is constantly in doubt if the cautery located deep in the bladder and not visible to the eye, is developing sufficient, if any glow at all, an uncertainty which is not removed through ausculatory control above the symphysis by the sizzling noise due to the burning, nor diminished by either the incalescence of the contacts, or the feeling of resistance on turning the wheel. In order to appreciate the great value of this improvement, it is necessary to do as I have done, operate at first without the ammeter and later on note the difference when using it. The charging of the accumulators must only be entrusted to reliable parties, or must be done under supervision of the physician himself, in order to be certain that it is performed in the prescribed manner and that the accumulators are actually completely charged. The accumulator manufactured for me by Louis & H. Löwenstein especially for the

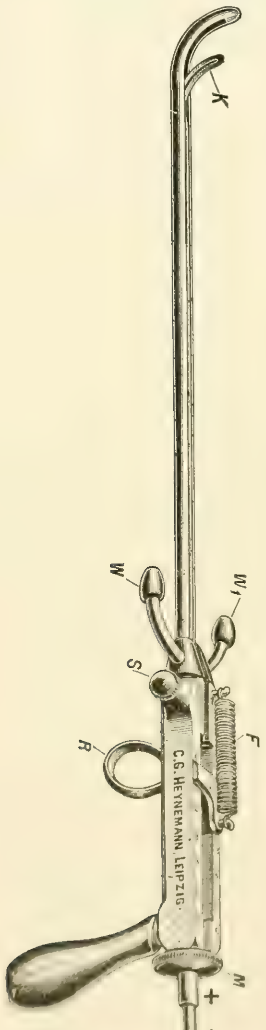


FIG. XXXIX.

Bottini operation, but which may also be used for all other galvano-caustic purposes, has proved entirely satisfactory; Fig. XL. Its serviceability and transportability are attested by the fact, that, in 1898, I performed an operation in New York with it, the charge having been supplied in Berlin, and that I constantly carried it with me on the trip, in carriages, trains and cabins. A larger pattern, which cannot therefore be carried by one person and has no greater serviceability than the smaller one, and has been manufactured by Hirschman (Berlin), Fig. XLI. With one charge of my accumulator, I have performed six Bottini operations successfully, but

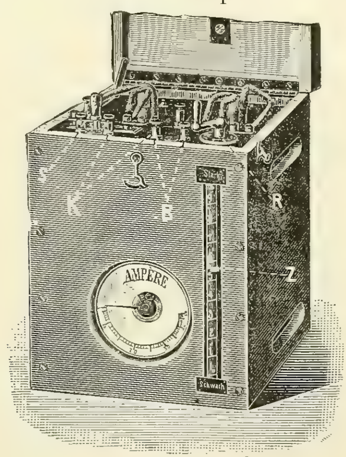


FIG. XL.

should not recommend doing more than three with one charge, unless a second one is in reserve. This is particularly required if some time should elapse between operations, and it is well known that accumulators, even when not used, gradually lose their charge. If the operations are performed three or four weeks apart, it is best to charge the accumulator anew before each Bottini operation. Even when not used at all, it is desirable to charge it every four to six weeks, as it is otherwise apt to deteriorate. It should not be forgotten, that the discharge of a current strength of fifty amperes always involves overtaxing of a transportable accumulator and that the plates

therefore cannot be expected to last as long as when the normal current discharge is utilized.

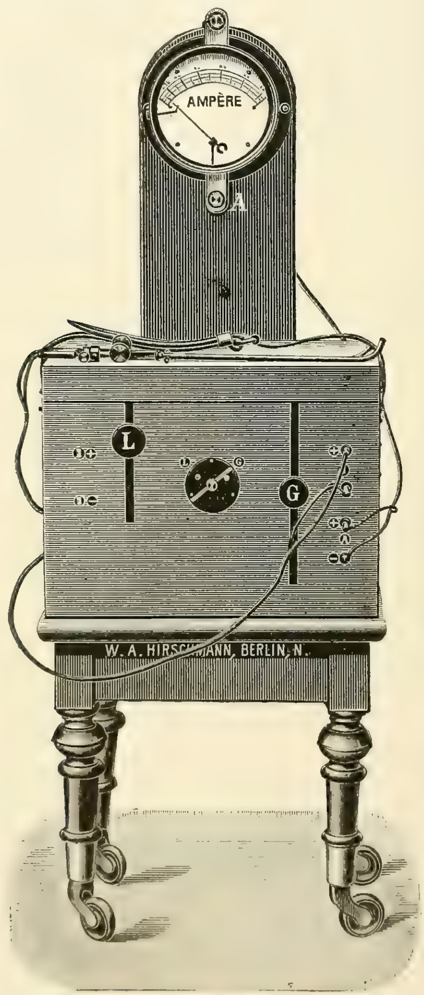


FIG. XLI.

It goes without saying that no objection can be urged if the street current is used in place of the accumulator, provided a suitable tranformer and reliable rheostat are employed and an

ammeter is attached. This arrangement is, however, not superior to the other.[1]

Technic of the Operation.—The technic of the operation appears remarkably simple. Nothing is seemingly more simple than to take the catheter-like instrument, be it cautery or incisor, introduce it into the bladder, turn the beak to the side where the groove is to be burned, *i. e.*, the galvano-caustic incision is to be made; then to operate the cautery, *i. e.*, through the turning of the wheel to make the incision of the required length, and to reverse the wheel, and after repetition of the cauterization, *i. e.*, after incising in one or several directions, to draw out the instrument. Nevertheless, it must not be forgotten, that a whole series of details are necessary to make the operation as free from danger and as successful as possible. Only if this is constantly borne in mind will good results be obtained. Those who are tempted to perform this operation indiscriminately, through its apparent facility, without observing all details, will be visited with failures of the most serious kind. They do wrong to lay the blame of these failures on the operation, instead of on the operator.

Preparatory to the operation, if severe cystitis is present, it should be improved as much as possible. Regular irrigations of the bladder or injections,[2] as well as the use of internal medication, such as urotropin, salol, acid camphoric, and others, and possibly the use of the retaining catheter, will be employed in the usual way. It is understood, that operations are contraindicated if fever is present or there is inflammation of neighboring organs (as epididymitis, etc.), also if an acute

---

[1] For a more complete description of the galvano-cautery see electro-physics.

[2] In ammoniacal cystitis I would recommend iodoform injections, although with great care to prevent iodoform intoxications, as I have seen iodoform psychosis supervene from its use. Since that time I inject at best, every two days, 0.3 grm. iodoform into the bladder and I find this sufficient in every way. If the reaction of the urine becomes acid or restless sleep and even mental irritation or hallucinations supervene, the remedy must be stopped at once.

or chronic septic condition of the patient is present. In preparation of the patient, a few days before operating, besides an exact general examination of the patient, cystoscopy should be practiced, the urinary organs and the urine examined (sugar, albumin, casts, etc). From these the condition of the bladder, as well as the presence of a cystic calculus may be determined.

If the latter exists, it must be removed before the Bottini operation, the choice of operation being usually litholapaxy with subsequent cystoscopic control. By means of cystoscopy the outline of the prostate gland may also be ascertained, showing how far it projects into the bladder, and based on the findings of the cystoscope, the direction of the incisions should be determined. Narcosis is rarely required. Local anesthesia of the pars posterior urethræ usually suffices to render the operation practically painless. It seems to make no great difference, whether eucaine (eucaine B), cocaine or a mixture of both is taken or possibly antipyrine, *i. e.*, antipyrine with eucaine or cocaine is employed. It also seems to be of minor importance, whether the anesthetizing fluid is injected through the whole urethra into the bladder with a syringe applied at the orifice of the external urethra, or whether it is merely carried through the pars posterior into the bladder by means of a catheter. Of course, in addition to the local anesthesia via the urethra and bladder, same may also be induced through the rectum by means of antipyrine, 10 grammes of a 10% solution being injected into the rectum one-half hour before the operation. But I prefer not to rely on this latter method. Lately I have always employed a solution of cocaine muriatic, eucaine B āā 1 gramme, to 30 c.c. aqua distill., same being injected via the pars posterior urethræ, preferably with the elastic "Mercier" catheter into the empty bladder, which had previously been washed out. Of course, care must be taken that the eye of the catheter is properly placed in the pars posterior and especially at its beginning so that its whole length is subjected to the action of the anesthetic.

It is important to wait from five to six minutes after the in-

jection, as it requires that much time until complete anæsthesia takes place. This interval may be employed by convincing one's self of the flawless efficiency of the instrument and of the electrical supply, before using the same.

In reference to the exclusive local anæsthesia, it is best not to be bound by any rule. With vigorous patients, who had previously been operated upon and stood narcosis well, or when long and numerous incisions are to be made, it may sometimes be more expedient to employ general, instead of local anesthesia. General anesthesia is certainly necessary, when, without it, the operator is unable to determine the faultless position of the instrument.

It is understood, that the whole armamentarium with which the patient comes in contact, must be absolutely sterile, not only the incisor, but also the hands of the operator; also the catheters, of which I always sterilize a number of various kinds in the steam sterilizer for three-quarters of an hour. Most of the good makes tolerate this very well, if care is taken that the different catheters do not come in contact (by inserting linen or blotting paper between them) and they are at once removed from the apparatus on completion of sterilization. The syringe, the irrigating fluid, the solution for anesthesia, the substance for lubricating the catheter (I prefer liquid paraffine), etc., should all be properly sterilized.

During the operation, the patient rests in a dorsal position on an ordinary operating table.[1] The operator stands to the right of the patient; on the left of the patient, resting on a small table, is the accumulator, placed in such manner, that the operator is always able to note the mark of the ammeter. In general, the technic of the operation, as I at present perform it, is as follows:

The bladder is washed out by boracic acid or any other antiseptic such as argentum nitricum, 1–2000 solution, this being

[1] The practice of some careless operators of performing this operation with the patient ambulant is absolutely to be condemned. An operation which may cause severe post-operative hemorrhages, or even, in rare cases, may end in death, must not be performed in the office.

followed by the injection into the empty bladder of the solution used for local anesthesia as described above. During the five or six minutes required by the anesthetic to produce complete anesthesia follows the re-examination of the instruments and appliances used for the operation, to determine their flawless efficiency. At the same time the rheostat is examined to note if it is so placed that the desired glow of the knife—I now always operate at white heat—may be maintained. Next the catheter, which I usually permit to remain in the urethra with the eye not in the bladder but in the pars prostatica, is again introduced into the bladder in order to permit drainage of the solution therein contained. The bladder is now filled with air, which is accomplished by means of the common graduated cystic syringe, which, instead of containing fluid, is filled with air. In order to have the air reach the bladder in sterile condition there is placed between the mouth-piece of the syringe and the catheter a cotton filter, composed of a glass tube 10 c.m. long, Fig. XLII, with a conical end, which is filled two-thirds with cotton and connected to the catheter

FIG. XLII.

and syringe by means of pieces of rubber tubing. I am careful to distend the bladder only moderately, so that the patient does not suffer from tenesmus or pain during the operation due to an overdistended bladder. I then usually permit the injected air to flow out of the catheter once or twice, primarily in order to determine if sufficient air has been injected into the bladder—although percussion over the symphysis will also determine this—and secondarily, to permit the discharge of the balance of any fluid which might still be remaining in the bladder.

Before the last definite injection of air, the buttocks of the patient are slightly raised through an interposed cushion or

by means of some appropriate arrangement on the operating table.

Now, the catheter, together with the attached syringe, is rapidly withdrawn, the left hand at the same time grasping the penis, and by compression, preventing the escape of air. The assistant next hands the well lubricated instrument (lubricated with sterile fluid paraffine), which is then, in the usual way, carefully introduced over the right thigh and groin, into the urethra. When the beak has entered the bladder it is immediately turned backward. With the help of the assistant, while the current at the accumulator is disconnected, the cable is then brought into firm contact with the instrument and one side of the cooling apparatus is connected with the tubing of an irrigator containing cold water, which is held up or hung quite high.*

Next the well lubricated index finger of the right hand protected by a rubber finger, is introduced into the rectum of the patient, and the correct position of the beak is exactly determined, *i. e.*, the point of the beak, which is directed backward, should be located precisely in the place where the prostate gland stops, and the proper wall of the bladder begins. The operator should not be satisfied with palpating indefinitely, but should not rest content until he succeeds in placing the tip of the index finger upon the point of the beak. I would say most emphatically that I have always been able to accomplish this, in spite of my medium-sized index finger, since I have paid especial attention to this point. In very large prostate glands it is necessary to press the perinæum vigorously upward, while at the same time the instrument is strongly drawn outward, and with a very bulky prostate gland the handle is also raised. Usually there is no difficulty in locating the point of the beak. On the other hand, it frequently

---

* In a cooling apparatus which acts well, the usual cold water without addition of ice will suffice. In the older instruments in which the current of water circulates somewhat slower, it is best to take ice water in order to secure positive cooling. Acquaintance with the instrument in use by previous testing of same will have elucidated this point.

happens that the point of the beak projects beyond the prostate gland, by bulging out the trigonum posteriorly, or by hooking into the rear of a hypertrophic inter-ureteral growth. The danger of commencing with the incision before this mistake has been rectified is quite apparent.

The withdrawal of the finger is next utilized to determine the length of the prostate gland and the required length of the incision dependent thereon. The finger glides along the point of the beak of the instrument over the prostate gland, estimating its length in centimeters, until the well-marked position is reached, where the prostatic portion terminates in the membraneous portion. From the length of the prostate gland thus obtained, four-fifths is taken for the cut posteriorly, while the incisions laterally and the incision (usually to be avoided) anteriorly, is made one-half to one c.m. shorter, excepting when it has been determined by means of the cystoscope, that at those parts markedly prominent masses of tissue projecting into the bladder are present. When the finger has been withdrawn from the rectum, the cooling process is started and the current at the accumulator is connected by the assistant. The operator now waits until the hands of the ammeter become quiet—(same oscillate at first)—which shows that the knife is evenly heated, and while the left hand grasps the handle of the instrument very firmly and steadily, the right hand, by means of very slow turning of the wheel, permits the knife to emerge from its groove and penetrate the tissues of the prostate gland. The eye of the operator must alternately watch the ammeter and the scale attached to the periphery of the instrument which registers the length of the incision, until the desired size has been reached. When this has been accomplished, the knife is slowly returned to its groove by reversing the turning of the wheel. The return may be performed somewhat quicker, but it is expedient, previous to the return of the knife to its groove, to proceed very slowly, in order to avoid squeezing non-burnt tissues into the groove of the beak. After the completion of the first incision, a second, third or fourth cut will be similarly made in

other directions. After that the cautery is extinguished by the breaking of the contact, the cable and the water supply are detached from the instrument and the latter is carefully withdrawn in the usual manner. The operation proper is completed.

Not infrequently the bubbling sound of the injected air may be heard escaping from the bladder of the patient via the urethra. The catheter is now again introduced, the bladder filled with a measured quantity of silver nitrate solution (1 ÷ 2000) or of boracic acid, and the patient is requested to urinate—while standing. If he is able to evacuate the quantity injected, excepting a very small residue, I do not as a rule, insert a retaining catheter unless other indications call for it. These latter may be: marked catarrh existing before the operation, unusually severe hemorrhage or difficulties in catheterization observed before or developing after the operation, or in cases where the catheter cannot presumptively be immediately dispensed with.

The After-Treatment.—After the operation, the patient is kept quiet and I confine myself, when possible, to practicing post-operative internal antisepsis similar to that employed before the operation, by administering for a number of weeks such well known internal remedies as salol, urotropin, acid camphoric, etc. This is, of course, not possible in all cases, as the success of the operation is not always immediate. On the contrary, it is frequently noted, that difficulty in the evacuation of urine is experienced, evidently due to the reactive tumefaction of the prostate gland. The results of the operation are first apparent, when the swelling of the prostate gland is again reduced, and after expulsion of the slough, and sometimes only after the contraction of the scar. With increased experience I have noted, that these initial, apparent failures grow less. Incomparably more frequent than formerly, immediate success is met with, often while the patient is still on the operating table.

When the patient voids the urine in a satisfactory manner, the catheter is preferably never employed, or but rarely to

determine the residual urine or for the purpose of washing out the bladder in existing cystitis. On the other hand, the catheter should not be used too sparingly, especially when retention of urine manifests itself. The theoretical fear of tearing off the slough has, in my experience, with careful manipulation of the catheter—I prefer the use of the elastic catheter—proven practically ungrounded. In the after-treatment, asepsis must, as a matter of course, be strictly adhered to.

If it is necessary to employ the catheter very often, or if its introduction is difficult, I do not hesitate to subsequently introduce a retaining catheter. Not infrequently, following the constant use of the retaining catheter, I apply same only at night for several days, leaving it out during the day. The length of time required for the retaining catheter to remain in the urethra depends on circumstances. The good action of same, the cessation of hemorrhage, as well as the more or less hypersensitiveness of the patient, must be considered. As a rule, I rarely permit the retaining catheter to remain more than three or four days, so that the patient may get up as soon as possible.

If urine escapes along the sides of the retaining catheter, the latter not being obstructed, this is to be taken as a fairly positive indication of complete success—which may properly cause the removal of the catheter at an earlier date than contemplated. As a matter of course, in the application of a retaining catheter, care must be observed that same is introduced lege artis, especially that it is not introduced too deeply, so that the urine will not gush out above the eyelet. I never connect the retaining catheter with a receptacle, but by means of a tube lead it into a bottle placed under the bed, a few thymol crystals being expediently placed in the bottom of the bottle. The tube is carried through under the knee (to prevent compression) preferably with an intermediate glass tube, and is fastened with safety pins in an appropriate manner to the mattress.

Bottini usually prescribes after the operation,—also often

before same—preparations of strychnine or extract of kola, in order to invigorate the musculature of the bladder. I have never been convinced of the action of these remedies on the bladder of the patient, although I am especially partial to the strychnine preparations, as they usually appear to have a very favorable action on the appetite of the patient.

Meteorism is usually noted in the first days after the operation—a few doses of common brandy, or peppermint tea, or a purgative, suffice to remove this symptom.

Details of the Technic.—After this general review of the operation and the after-treatment as I carry them out, I cannot forbear treating more minutely of several points which are still in dispute or are of especially great interest.

(1) **Should the operation be performed with an empty or a full bladder, or with a bladder filled with liquid or with air?**—Bottini primarily operated on the bladder filled with liquid, and subsequently on the bladder when empty, as he believed that the liquid checked the action of the glow.

Personally, at the beginning, I operated according to his directions with the bladder emptied, but after an accident (injury to the bladder wall) I dispensed with it and adopted the operation in which the bladder is filled with liquid. With this method undoubted complete success will be obtained, provided the operator uses white heat. Later on, I began as explained above, to operate with the bladder filled with air, according to the method of Bransford Lewis. After operating in this way forty-three times, without at any time noting the ascension of air into the ureters or even embolism of air as experienced in the Lewin-Goldschmidt experiments on animals,* I can urgently recommend this procedure.

(2) **The Degree of Heat of the Knife.**—Bottini applies red heat of the knife (cherry red), but when drawing back the knife increases the current in no small degree, through regulation of the rheostat, so that I assume, that the knife is practically

* Deutsche Med. Wochenschrift, 1897. No. 38, page 601, and No. 52, page 825. Archiv. fur Experim. Pathologie and Pharmac., Vol. xl, 1897, pages 287 and 308.

close to white heat on its return passage. After having at first followed Bottini's method, I now, with others, employ white heat from the beginning. The greater tendency to hemorrhages, as feared by Bottini, I have not observed. In five cases of severe hemorrhage in my experience, three took place while I still used red heat, and the number of operations I have performed with white heat now far outnumber those of the former. I consider the use of white heat distinctly necessary when operating on a bladder filled with fluid. The current is increased intra operationem only when I feel that the knife meets with resistance in the tissues, or when the hand of the ammeter goes backward. This occurs not infrequently in operations of long duration, due to calefaction along the course of the current, noted at the rheostat, the cable, the points of contact, etc., thereby producing increased resistance.

In this connection I would add, that, on the other hand, through cooling of the knife within the tissues, the constant observation is explained, that after introduction of the instrument and after commencement of the incision, although the position of the rheostat remains the same, the current strength is greater, the ammeter showing 2 to 5 amperes more than at the previous trial in the open air. That this manifestation is, in fact due to the cooling of the knife, may be confirmed in the open air aside from the operation, by bringing moist cotton, etc., in contact with the knife.

The current strength with which I operate at white heat corresponds with my incisor to about 45 to 48 amperes on trial in the open air, which, as outlined above, corresponds to 48 to 52 amperes when the instrument has been introduced into the bladder.

(3). **Slow Incision.**—It is of the utmost importance especially in order to obviate hemorrhages, to direct the knife very slowly through the tissues. For an incision to and fro of 1 c.m. I calculate 1 to 1¼ minutes. Bottini figures 1 minute for ½ c.m., Viertel, for instance, incises still slower.

(4). **Length, Depth, Direction and Number of Incisions.**—The suc-

cess of Bottini's operation depends on the proper direction of the incision. Castration for the removal of hypertrophy of the prostate gland can be performed successfully or poorly; whether the patient is to derive benefit from the operation does not, as a whole, depend on the more or less successful technic with which this operation is performed. On the other hand, in Bottini's operation, everything depends on the manner of its execution. The same case, which, with a given operator or on the first trial proves to be an absolute failure, will, in the hands of another operator or upon second trial, with proper modifications, prove most brilliantly successful. Among the many details to be considered in this connection, the proper choice of the length, depth, direction and number of incisions is, in addition to the possession of a flawless armamentarium, of the greatest importance. These points are decided by the preliminary cystoscopy on the one part, and the examination of the prostate gland per rectum on the other part. By means of cystoscopy, the bulgings of hyperplastic prostatic tissue projecting into the bladder are located and in these directions the incisions are executed. It is, however, not always necessary or expedient to direct the incision to the apex of the hyperplasia. It may even be expedient in certain cases, to have the incision placed in the hollow between two pads of hyperplastic tissue, as is preferably practiced by Bottini. A variation of this incision into the hollow, which is sometimes to be recommended, is the method of Young in making the incision through the middle lobe. This is not, however, as Young designates it, a special method for operating.[1]

Young makes his incisions on both sides of the middle lobe, conveying them towards the base of the lobe. Personally, I prefer in such cases, to make an incision directly over the center of the middle lobe in addition to the lateral incisions. As a general proposition, when in doubt, it is better to make an extra incision rather than to incise too little. On

[1] Monatshefte für Urologie, 1901. Vol. VI, page 1.

the average I make three incisions for a single operation, usually one posteriorly and respectively one to the right and left. This corresponds, according to my experience, to the most frequent configurotion of the prostate gland in which the bulging hyperplasia is found, co-existing posteriorly and on both sides. I have, however, sometimes used but one incision and at other times found it necessary to make as many as five incisions in different directions.

An incision anteriorly, *i. e.*, toward the symphysis, should only be made in those cases in which marked hyperplasia is noted anteriorly on cystoscopy, which acts as a hindrance to micturition. Otherwise, the incision anteriorly should be entirely avoided whenever possible, as it is in this location, owing to the slight thickness of the prostate gland, that the knife is apt to penetrate readily into the paraprostatic tissue, which in this region is supplied with large venous trunks, producing as dangerous sequellæ severe hemorrhages, abscesses and infiltration of urine.

The depth of the incision is dependent on the one hand on the fact that the instrument be firmly pressed upon the prostate gland, on the other hand on the height of the knife. I possess knives of various sizes, from 0, 8 to 1, 5 c. m. in height and choose between them dependent on the thickness of the prostate gland. As an average size 1, 2 c. m. is to be designated; my instruments are supplied with this size unless another size is especially ordered. The incision may also be deepened if the instrument is firmly pressed down and the knife is moved to and fro, for a second time, along the furrow. In general, however, this is not expedient.

The method of obtaining the required length of the incision, intra operationem, with the instrument in place and the beak turned posteriorly, with the finger in the rectum of the patient, has already been minutely described above. According to same, the incisions vary from 1, 5 to 5 c.m. in length. I have not, as yet, found it necessary to make longer incisions than 5 c.m. Such lengths are, however, not infrequently required. It is a mistake to suppose that only the hyperplastic bulgings

into the bladder produce difficult micturition. Hypertrophies toward the urethra manifested usually by a massive tumor in the rectum, can, through compression, misplacing or bending over the prostatic urethra to a more or less degree completely prevent evacuation of the urine. The hypertrophies often extend toward the bladder and urethra at the same time. In such cases, in order to achieve complete success, the incisions must be carried until close to the pars membranacea, but in order to avoid enuresis, no further. I soon became convinced of the importance of the proper length of the incision, and also at the same time of the fact that the old instruments with their possible length of incision of 3–3, 6 c.m., were not suitable in many cases.[1]

For that reason my new instruments are all so arranged that they permit an incision of 6, 6 c.m. Of course, this length of incision will be completed in but very rare instances; personally, I have not as yet found it necessary to increase my incision above 5 c.m. The great danger in employing even this latter incision in a short prostate gland, which possibly can be severed with a cut of 2 to 3 c.m. is readily apparent; injury to the pars membranacea or even of the anterior urethra or even of the perineum with an incalculable number of sequelæ (infiltration of urine, etc.) would be the inevitable result of such lack of consideration.

(5) **Shall the operator have his index finger in the rectum of the patient during the incision?**

We have seen that, in order to have control of the proper position of the point of the beak, and in order to determine the length of the incision, it is necessary before commencing the incision proper, to introduce the index finger into the rectum of the patient. It must just as strongly be emphasized not to keep the finger in the rectum during the operation nor to permit an assistant to introduce his finger into the rectum, as some operators of small experience advise.

---

[1] The original Bottini instrument permits an incision of 3, 2 c.m. my original incisor an incision of 3, 6 c.m ; the Hirschmann instrument of but 3, 0 c. m.

This procedure which may be profitably employed with the prostatic cautery in order to press the prostate gland firmly against the glowing surface, is to be strictly condemned in cases where the incisor is used. When the finger presses against the knife, which, owing to the incalescence becomes soft, same can with difficulty be prevented from turning to one side from 1 to ½ m. m. When the knife is then reversed, it will be unable to enter the groove of the female beak, pass to its side, and will become bent still more, so that difficulty in the withdrawal of the instrument, as well as hemorrhages and injuries to the urethra, will be sure to follow.

Complications During and After the Operation.—Among the complications which may occur during the operation are:

(1) The bending of the knife: That the index finger kept in the rectum during the incision may produce such bending we have just noted. In addition to this, the other main causes for such an occurrence are:

(a) Insufficient heat of the knife.

(b) Too rapid incision.

(c) The grasping of the handle in an unsteady manner.

In order to permit a firm grasp of the handle, I have purposely constructed the handle of my modified instrument in such manner that it may be held firmly in the fist, and is also protected from getting heated by means of the water passed through it for cooling purposes. When, for instance, the handle is not grasped firmly, but is permitted to swerve, even if only slightly, from its longitudinal axis, the female beak will also move in the corresponding direction and the knife, being lodged in the tissues of the prostate gland, is unable to follow; it therefore gets into another plane from the beak, and on its return journey fails to reach its groove. The subsequent sequelæ have just been described.

That, in addition, the moving of the patient also plays a part, is quite apparent. A theoretical possibility to account for the bending of the knife would be found in the presence of prostatic concretions, but I have not, as yet, experienced the latter in the Bottini operation.

(2) **Hemorrhages.**—The Bottini operation is generally performed, especially with an indurated prostate gland, with but remarkably slight hemorrhage, which, after twenty-four hours, entirely disappears macroscopically. Severe hemorrhages in the first twenty-four hours, and such occurring later, about the tenth to the fourteenth day following the expulsion of the slough, are, especially in soft prostate glands, not very rare.

In five cases I have seen quite severe hemorrhages, which extended over several days, but special interference was not called for on that account. By the use of styptics (ergotin, hydrastis, gelatine, etc.) and of the retaining catheter, the hemorrhages eventually subsided spontaneously. In some cases, where, owing to the fact that the bladder becomes filled with blood, the patient suffers from frequent tenesmus, an injection of morphine by subduing the tension produces a styptic action.

Some operators have performed sectio alta to stop the hemorrhage. There can be no doubt that same should be thought of when the operation is followed by filling and plugging up of the bladder and the urethra. I am inclined to believe, however, that in many of the described cases, the operation was performed without urgent reason. At all events, it should not be attempted until general symptoms of anæmia are present, such as poor pulse, spells of fainting, vertigo, etc. Theoretically it might be considered whether the reintroduction of the incisor and vigorous repetition of the cauterization might not act well. Practically this would be useless, as the place of the bleeding cannot be located. The cystoscopic incisors—which will be described later—would also prove useless in these severe hemorrhages as nothing can be seen through them in such cases.

(3) **Acute Retention of Urine.**—Success of the operation is frequently noted immediately following it, yea, even while the patient is still on the operating table. Not infrequently good results are first noted after a number of days, after cessation of the swelling of the parts, expulsion of the slough, or im-

provement may be delayed until after cicatricial contraction has taken place.

It seems to me, that only such cases are immediately successful, following a flawless operation, in which the hindrance to micturition is due to hyperplasias toward the bladder; while in cases which the hyperplasias are also toward the urethra, prove successful somewhat later. In such cases, it is not rare to find during the days following the operation, that some difficulty in micturition or catheterization is experienced, which may increase into complete acute retention. This does not, however, as yet permit a poor prognosis upon the successs of the operation and does not justify immediate repetition of the operation. It behooves us rather to await results and by means of frequent catheterization or the application of the retaining catheter (strict asepsis) as well as possibly by the use of sedatives, as morphine or belladonna suppositories, to tide the patient over the difficulties of this period.

I found it necessary to perform capillary puncture of the bladder above the symphysis on but one occasion, when catheterization was impossible, owing to reactive tumefaction of the tissues. In this case, also, I was able to introduce the catheter after a few hours, which, of course, was then kept there as a retaining catheter.

(4). **Injuries to the Bladder-Wall.**—Injury to the trigonum and cutting through of a transverse fold of the bladder-wall, which had been drawn to the prostate gland, has occurred, the latter due to operating with an empty bladder. Such occurrences can be prevented with certainty, if the principles of the technic as described above, are closely followed. The dangers following the incision anteriorly, have already been discussed.

(5) As sequellæ of such injuries to the bladder, suppurative thrombophlebitis, pyæmia, peritonitis or infiltration of urine may supervene. Pyæmia may also occur in another way, especially from infected pelves or kidneys, if same had already been infected before the operation. These complications are, however, luckily very rare and with proper technic on the one hand, and timely operation on the other, *i. e.*, before the kid-

neys are affected, can usually be avoided. The importance of operating with sterilized instruments and in observing after-treatment is self-evident.

(6). **Catheter Fever.**—Not to be confounded with pyæmic chills are the mild chills which correspond to the picture of the so-called catheter fever, and are not at all infrequent. They come on with the patient in excellent health during the first or second, sometimes also the third twenty-four hours after the operation. The temperature rises in these cases in a few hours to 39° or 40° c., in rare cases to 41° c. (105.8 F.), or even higher. The chilly stage which usually lasts for one-quarter to one-half hour is followed by a marked stage of heat upon which follows abundant sweat during which the temperature usually declines as rapidly as it had risen. Sometimes vomiting takes place and with high temperature mild stupefaction or delirium may also supervene, but the condition of the patient does not suffer much as a whole, excepting during the short chilly stage, and he is, especially after the expiration of the attack, usually immediately restored to health. As a rule, the temperature and the progress of the patient later on remains entirely normal, but a chill may return on the next day—usually with diminished temperature or in its stead a simple increase of temperature by fits and starts, may take place, without marked chill. A positive prophylactic remedy for this catheter fever has not as yet come to my notice; perhaps we may in the future, by means of bacteriumtherapy or serumtherapy succeed in finding such an agent. It may be assumed with certainty, that this fever is occasioned by the absorption into the circulation of bacteria or bacterial toxines. It should be particularly desirable to find a prophylactic remedy for this affection, as it may, at the beginning, be mistaken for true pyæmia, although the slight general pyrexia before and after the attack of this fever usually predicates in favor of the catheter fever. In the meantime I have successively used urotropin, salol, natr. salicyl., uva ursi, santol, quinine, methyleneblue, singly or in combination, without

avail, to prevent this trouble. At present, I employ acid camphoric t. i. d. 1.0 grm. to the same end.

Aside from this catheter fever, there is also usually in the first days after catheterization a mild, insignificant increase of temperature to 38.5° c. (101.3°F.). Entire apyrexia may be counted upon during the procedure, when the patient comes to the operation with entirely clear urine and the operation and after-treatment are carried out aseptically.

(7) **Enuresis.**—In the first weeks after the operation, especially if the operation has been completely successful, there ensues not infrequently a certain degree of involuntary micturition. This usually ceases in course of the first month following the operation; in rare cases it lasts for about a quarter of a year and even longer. In exceptional cases, enuresis may remain permanent. In such cases suspicion must always be entertained that the incisions have been made too long and that the sphincter externus has been injured. It is, at all events, highly probable that the latter in many cases of the Bottini operation, assumes the function of closure of the bladder, and its injury, therefore, produces enuresis. On the other hand, in cases where enuresis existed before the operation, it ceases after a successful Bottini operation. It may safely be assumed, that this kind of enuresis only takes place from over-distention of the bladder and is, therefore, a case of so-called "paradox incontinence of urine."

(8) **Epididymitis and Orchitis.**—Not infrequently epididymitis and orchitis may supervene after the Bottini operation, same being also not rare in prostatic hypertrophy due to catheterization. It is rare for such orchitis to become purulent, requiring incision. This is, however, an occurrence which will also be met with in cases of prostatic hypertrophy which have not been operated upon.

Repetition of the Operation.—The more experience one gains in the Bottini operation, the more frequently is complete success vouchsafed immediately at the first seance. Nevertheless, the most experienced operator will sometimes not be able to stop with one operation. If there has been no success, or if the

operation has been only half-way successful, it should be repeated. This, unfortunately, may sometimes be frustrated by the objection of the patient. The physician should not permit theoretical discussions, such as: that a repetition of the operation will be useless owing to the fact that the bladder had already been weakened too much, prevent him from making a new attempt. Bladders which have not been able to spontaneously evacuate a drop of urine, can recuperate, and frequently do so in a quite surprisingly rapid manner, as soon as the impediment to the discharge of the urine has been completely removed. The more experience I have gathered in course of time, the more I feel justified in claiming, that a satisfactory removal of the impediment to micturition is the essential point for the success of the operation, and that the supposed weakness of the muscular structure of the bladder, when at all, can but in exceptional cases be held responsible as an explanation for failure. Complete failure can, however, never be explained on this basis.

When Shall the Operation be Repeated?—Regarding the interval when the operation should be repeated, it is difficult to formulate set rules. I have repeated the operation as early as six days after the first, and in cases when the patient originally refused, after expiration of some years.

The vitality of the patient, the degree of success accomplished and the reaction displayed after the surgical interference must be considered. As a rule, I do not, at present, care to repeat the operation until the twelfth or fourteenth day, for, as already mentioned, not infrequently the diminution of the swelling of the tissues and the expulsion of the slough may still be progressively noticed during this period, and may go on to complete restoration.

Recidivation.—Even with complete success, depending on the progressive character of the hypertrophy of the prostate gland, relapses may be noted. Nevertheless, they are extraordinarily rare. Among all my cases I number but one positive case of relapse, with one or two probable ones. When relapse occurs, the operation is to be repeated. The repe-

tition has the same chance for success as the first operation. Not to be confounded with true relapses are the aforementioned semi-successful cases, which should have been again operated upon in the first place.

Indications and Contraindications.—The attempts to find indications for the Bottini operation from the size and hardness of the prostate gland, depending on the fibrous or glandular character of the anatomical substratum, must be considered failures. It is of just as little importance for purposes of operative indication whether a posterior or lateral lobe exists, whether the bulgings are only towards the bladder or exclusively toward the urethra. All these circumstances must certainly be considered as a guide for the operation, or partly also for prognosticating a rapid or slow appearance of success; for the question whether an operation is indicated, they are, generally speaking, of no importance. No matter how exaggerated it may sound it must nevertheless be affirmed, that the Bottini operation is suitable for all forms of prostatic hypertrophy.

The question whether the lack of functional ability of the bladder-wall should be considered as a contraindication has, as already explained, no practical importance; as a matter of fact, as I must constantly emphasize, the weakness of the bladder walls is not the cause of deficient micturition in cases of prostatic hypertrophy, but it must rather be sought in the impediments to the evacuation of the urine due to the hypertrophy of the prostate gland.

The indication for the operation should depend, as a whole, upon the stage in which the patient comes for treatment, as well as upon the nature of his complaints. Certainly patients in the very first stage of the disease, with probably somewhat increased desire for micturition, causing them to get up once or twice during the night, but otherwise in undisturbed general health, do not present indications for operative interference. Neither is it indicated when the complaints increase somewhat and when digestive disturbances, which frequently occur in this stage (such as lack of appetite, disgust for meat,

dry tongue, excessive thirst, etc.), and which are probably due to renal congestion, are added. These complaints may frequently be removed or sufficiently ameliorated for many years, by attending to the bowels, occasionally having strictly aseptic catheterization,[1] sometimes introduction of the Beniqué sounds with gradually increasing size, etc.

A case of primary acute retention I do not as yet consider as an indication for operative interference, and certainly not, if after cessation of the acute retention control is regained, so that the bladder can again be almost completely evacuated. Possibly the cautery will be used more frequently in the early stages in the future than it has been heretofore; these cases are certainly not as yet suitable for the incisor. The case assumes a different aspect when the acute attacks of retention are repeated more frequently and especially at short intervals. Here an indication for the operation with the incisor may already be found and same must certainly be performed if a recurrence takes place very frequently or when external conditions make it difficult for the patient to at once receive proper medical attendance. The indication for the operation which I consider certain and urgent presents itself at that moment, when, without operation, I would be compelled to hand the catheter to the patient permanently. The use of the catheter by the patient himself inevitably leads to infection, from which one can never tell, whether it will confine itself to the bladder, or, ascending through the ureters lead to pyelitis, pyelo-nephritis and lethal urosepsis, thus demonstrating the well known fact, that self-catheterization very frequently presents the beginning of the end.

The best results are, of course, secured with the Bottini operation, when infection has as yet been excluded, as this constitutes its main danger. And this infection is almost ex-

[1] I always follow catheterization, which is invariably performed with absolutely sterile instruments, with an injection into the bladder of from 20 to 30 c.c.m. of argentum nitricum 1:2000 solution, and in order to have simultaneous internal antisepsis, I have the patient take salol or urotropin internally.

clusively produced by non-aseptic catheterization. Such cases in which cystitis supervenes spontaneously without previous catheterization are, in comparison with above, so rare, that they may practically be left undiscussed.

In this connection, I cannot refrain from again admonishing the practitioner not to hand the patient a catheter for self use in these cases, but to have the Bottini operation performed in seasonable time.

The indications are more difficult to point out when the parts above them are affected than when those below are involved. If infection of the pelvis of the kidney or of the kidney proper already exists, the operation can certainly be no longer considered without danger. But even in these cases, the operation will often be attended with good, yea, life-saving results. In such cases, however, where simple catheterization, a cystoscopic examination or the introduction of a sound presents an interference not unattended with danger, the employment of the Bottini operation even with most correct technic will sometimes be followed by the death of the patient from sepsis or pyæmia. Whether the patient should nevertheless be advised to undergo the operation even in this stage, can only be determined by the case at hand. The danger of the operation in such cases on the one hand must be carefully weighed as compared with the danger and impairment of life as presented by the disease on the other hand.

Such patients should not be excluded from the operation, however, at the outset, for the reason, that owing to their severe affection the operation is most urgently required and just in such cases, the operation when successful, will result in a direct saving of life. The patients or their relatives must, however, be advised of the danger of the operation beforehand. That the operation should, if possible, not be performed when fever, epididymitis, or acute, or chronic urosepsis, etc., are present, but that the favorable moment should be awaited until by proper preparatory treatment the chances for the operation are improved, has already been explained.

Statistics of the Bottini Operation. Statistics compiled by me

in October, 1900, comprising my own operations and those contained in the whole literature of the subject,* in which 753 cases had reference to the mortality, 718 to the success of the operation, showed 4.25—5.84% mortality, 7.66% failures, and 86.63% "good results," *i. e.*, cures plus marked improvement. Among 248 "good results" which could again be subdivided, 152 (61.29%) were designated as "cures," 96 (38.71%) as "substantial improvements." By the term "cure" is understood that the patients could entirely dispense with the use of the catheter for the evacuation of the urine, that they could micturate absolutely without inconvenience as to frequency, with a clear stream and without difficulty, and that the residual urine had entirely disappeared or had diminished to an insignificantly small quantity of say 50 c.c.m.

It is self-evident, that with a "cure" and also in cases of "substantial improvement," marked improvement of the general health, characterized especially by a considerable increase in weight, enhancement of the appetite and removal of the symptoms referable to the alimentary canal are noticeable. As an especially agreeable supplement to successful Bottini operations may be noted the almost entire removal of obstinate constipation existing prior to it.

The above-mentioned statistics undoubtedly present very good results. There is, however, no doubt that the results in the future will be still better when it becomes possible, as outlined above, to receive the patients more timely for the operation than is at present the case. On the other hand, results will also improve, when the technical instructions as explained above and as approved by practical experience, will have become more than heretofore, common property of those who perform the Bottini operation. That, with increasing experience, the success of the individual operator will be constantly enhanced, is easy to perceive, especially in this operation, which requires exact attention to so many technical details. Perhaps I may be permitted to cite as evidence of this fact,

* Centralblatt f. d. Krankheiten der Harn—und Sexualorgane, 1900, Vol. IX, page 513.

that among my last nineteen cases there were noted no less than sixteen cures, two substantial improvements, and only one failure.

Taken all in all, no doubt can exist that the Bottini operation should have first place among all operative procedures having reference to hypertrophy of the prostate gland, and that even now it can be designated as one of the most beneficent achievements of modern surgery.

Supplement—Cystoscopic Incisors.—In order to perform the Bottini operation under supervision of the eye, Wossidlo first constructed an instrument, called by him "Incision-cystoscope," in which the male portion, carrying the knife, and the optical apparatus for cystoscopy, are placed side by side.[1]

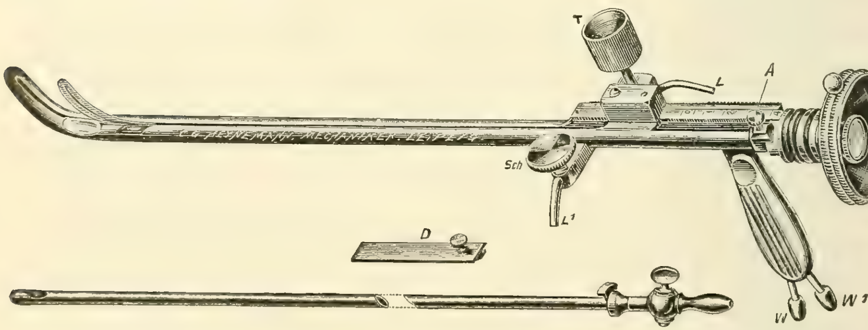


FIG. XLIII. Incisor-Cystoscope. The Lower Piece Rrepresents a Catheter which can be Introduced in place of the Cystoscope.

The construction is explained in the adjoining cut, Fig. XLIII. I was obliged at the time to offer several objections to this instrument.[2]

The most important of these objections I even now still consider to be the fact, that its application precludes the hooking on to the prostate gland of the beak of the instrument, because, as is readily seen from the cut, the prism and lamp

[1] For a more exact description of same see: Centralblatt f. d. Krankheiten der Harn—und Sexualorgane, 1900. Vol. XI, page 113.

[2] Berliner Med. Gesellschaft, Session of Jan. 31, 1900. Berliner Klin. Wochenschrift, 1900, No. 8, page 173.

are located on this side of the beak. The importance, however, of firmly hooking the beak to the prostate gland so that the beak is exactly located where the prostate gland ceases and the bladder-wall proper commences, has been elucidated above.

On this proper placing depends the whole safety of the procedure, the length and depth of the incisions and with these the success of the operation.

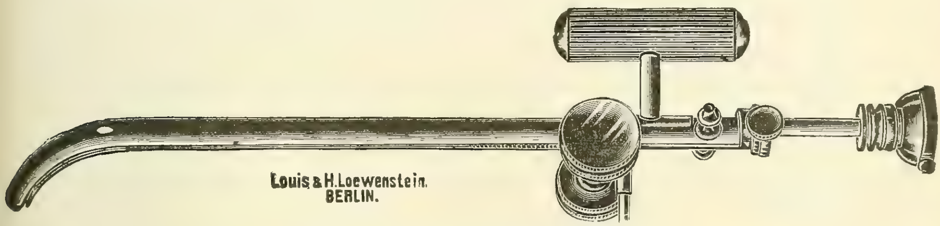


FIG XLIV. Instrument Closed.

FIG. XLV. Instrument Open. Cystoscope Protrudes.

Later on, jointly with Dr. F. Bierhoff, I constructed a "cystoscopic prostatic incisor" which I believe meets the desideratum of operation under control of the eye without introducing new, vital defects into the technic of the operation.[1]

The instrument manufactured by the firm of Louis and H. Löwenstein. Figs. XLIV and XLV. permits, above all, of the firm hooking on of the beak to the prostate gland in the same manner as was the case with the hitherto typical instruments. It has a perfectly straight cystoscope which can be turned and shifted from a tube attached to the posterior surface of the

[1] Centralblatt f. d. Krankheiten der Harn—und Sexualorgane, 1900, Vol. XI, page 571.

shaft, while the conduction to the platin-iridium knife is placed in a groove on the anterior surface of the shaft. This conduction has attached at its periphery a small, cogged plate into which a cog-wheel fits, by means of which two larger lateral wheels may be turned. The turning of these wheels moves the knife to and fro; the scale attached to the periphery of these wheels permits the registering of the desired length of the incision. The instrument is introduced in a closed condition, the cystoscope being used as an obturator. After the beak has completely entered the bladder, the cystoscope is pushed forward and by turning the beak to one side to remove it from view, the bladder and prostate gland may be explored cystoscopically. The location in the prostate gland which is to be incised is exactly noted, the beak is moved to the place determined upon, during which it can be clearly noted whether the beak really becomes located on the desired spot; the cystoscope and the other parts of the instrument are then fixed in this position by a screw located at the peripheral extremity which controls a muff and then the incisions may be made to the desired extent by means of the graduated wheels. The longest incision possible with the instrument is 4¾ c.m. If quite severe hemorrhage should occur during or after an incision, rendering it desirable before making a new incision to have a new lavage of the bladder or should the lamp burn out during the operation, the cystoscope can be removed by simply drawing it out and the bladder may then be washed out and again filled through the tube which acted as a receptacle for the cystoscope. The cystoscope is then reintroduced; all this is done without having been obliged to remove the whole instrument from the bladder. It is expedient, in performing this technic, to apply one of the well known Janet rubber-points to the mouth-piece of the syringe used for the lavage of the bladder.

As a matter of course, the instrument is also supplied with the customary water cooling apparatus. Connection of the cystoscope with the cable of the light accumulator is accomplished by means of the usual contact; the connection of the

knife with the cable of the galvano-caustic accumulator by means of a concentric contact running perpendicularly downward from the periphery of the instrument. Excluding the cystoscope, the instrument will be sterilized by simply boiling it; the cystoscope may be readily disinfected by fluid disinfectants or formaldehyde gas as it has a completely straight smooth cylindrical rod without any indentations. The diameter of the instrument, as it has an oval cross-section, measures from before backward 30—from right to left 22—therefore averaging 26 Charrière. It has therefore, undoubtedly a greater caliber than the old Bottini and Freudenberg incisors which measure but 21–22 Charrière. This caliber can, unfortunately, not be avoided, owing to the presence of the optical apparatus, as otherwise the field of vision would be too much diminished.

To grasp the instrument firmly, a grooved cylindrical handle is fastened parallel to the shaft, which, as has proven so successful in the old Freudenberg incisor, is also clasped with the whole fist. If this instrument is to be employed, the patient must be put in the appropriate gynæcological position as used for cystoscopy, while the physician sits in front of him, between the limbs. On one side is the accumulator for the lighting, on the other side the accumulator with the ammeter for the Bottini operation, the observation of which must be left to an assistant. Whether the operation with this instrument can be performed with the bladder filled with air, or whether it will be necessary to preferably return to the operation in which the bladder is filled with fluid, must depend on experience. In the single case in which I employed the new instrument, I operated with the bladder filled with fluid. At all events, it is not to be expected that the new instrument will be suitable to replace the old typical instrument and the old typical procedure in all cases. Personally I must confess, although I had almost ideal results in the single case in which I applied the new instrument (see case 3) that I still prefer my old instrument. Possibly this is due to the fact that I am particularly practiced with same and therefore achieve results

with it which cannot be improved upon. At the outset, it is well to avoid employing the new instrument when (1) the bladder can be but slightly extended, when (2) on introduction of a simple metallic catheter there exists a tendency to severe hemorrhages, when, (3) the prostate gland is especially large and hard.

SELECTED CASES OF BOTTINI OPERATION.

Case I. Complete retention of urine existing for the past 3 1-2 years. Castration, without success, 3 years ago. Immediate cure by means of the Bottini operation. Cure still operative, 4 years after the Bottini operation.

Mr. O.—Feed-dealer, aged 63, was referred to me by Drs. L. Casper and Haike. Had previously been treated by me in 1893 for hypertrophy of the prostate and severe cystitis. The residual urine at that time was 700–1000 c.m. Since the last of 1893, or the beginning of 1894, complete retention of urine supervened.

On June 5, 1894, bilateral castration was performed by Dr. Casper. Same was absolutely without success. After it, patient could not evacuate a drop of urine except by means of the catheter, which he was compelled to use of late from 4–5 times in 24 hours.

April 25, 1897, (after a period of complete retention of urine lasting 3½ years, almost 3 years after castration) the Bottini operation was performed, with cocaine and an empty bladder. Three incisions were made; one each 3 c.m. in length backward and to the left, and one 2 c.m. in length anteriorly.

As early as 5½ hours after the operation, the patient was able to spontaneously evacuate 6 c.c.m. of urine, followed during the night with from 1–7 c.c.m. On the second day after the operation, quantities of up to 55 c.c.m. were noted; on the third, 132 c.c.m., at one sitting. On the 7th of May (10 days after the operation) a residual urine of only 55 c.c.m. is noted. As early as the second day after the operation the patient is catheterized only in the morning and evening; from

the 18th day onward (May 15th) only once a day; from the 34th day (May 31st) the patient has no further use for the catheter at all. The residual urine amounted to, towards the end, in the morning, from 11 and 40 c.m.m., in the evening, from 15 and 52 c.c.m. Temperature on the 5th day after the operation 38 C. (100.4 F. 4 F.), otherwise never over 37.5 C. (99.5 F.).

October 20, 1897. Patient is presented to the Berlin Medical Society. Is able to urinate with good stream, 6–7 times, rarely 8 times in 24 hours. The former constantly cystic urine has since about 3 months become as clear as gold. Former persistent constipation has completely disappeared. Has gained 7 lbs. in weight since the operation.

Status November 28, 1899, (2 7-12 years after the Bottini operation). Urine is absolutely clear. Urinates 6–10 times in 24 hours, the latter number only when he responds to every slight urging. During the course of these years, has had several mild attacks of cystitis, probably due to catching cold, which, however, were always cured by urotropin within several days. His weight has increased right along, so that he now weighs 21 lbs. more than at the time of operation (198 instead of 177 lbs.).

Last report March 21, 1901, (3 11-12 years after the Bottini operation).

Has never been obliged to return to the use of the catheter. Urine clear. Urinates usually 8 times in 24 hours, always responding to mild urging. Can, when he wishes, hold his urine during the day for over 6½ hours. At night time he sleeps without arising from 10–5 o'clock. Weight at present 196 lbs., has in the mean time weighed as much as 200 lbs. (23 lbs. more than before operating). Examination of the residual urine during the course of years resulted in: July 1, 1897, 52; July 13, 1897, 50; July 8, 1898, 38; Sept. 15, 1898, 34; Feb. 3, 1899, 45; May 18, 1899, 24; May 20, 1899, 27; Nov. 28, 1899, 58; April 17, 1900, 40; March 21, 1901, 62 c.c.m.

Case II. Complete retention of urine for 5 years; very frequent attacks of epididymitis; first Bottini seance almost with-

out success, second partly successful, third, complete cure. The cure after over 3½ years since the last seance is still constant. Attacks of epididymitis have also been removed.

Mr. C. P., mason, aged 67½ years. Sent me for operation by Prof. Posner. Has had urinary troubles for 6–8 years; for almost 5 years absolutely complete retention of urine. Catheterization 2–6 times in 24 hours. The urine which was very turbid and malodorous, is, at present, after the use of urotropin and from regular lavage of the bladder, only moderately turbid. Very frequent attacks of epididymitis, sometimes left sided, then right sided, at times every 8–14 days or even more frequent of late. Has lost 12 lbs. in weight during the past year. The prostate gland toward the rectum is but slightly prominent, soft and smooth, and the upper border can barely be reached.

May 19, 1897. First Bottini operation with empty bladder; 3 incisions, one cut each 3.3 c.m. backward and to the left and one cut 3. c.m. forward. The instrument (Bottini's original incisor) acts with difficulty in the last incision. Knife is bent on withdrawal. The accumulator (Bottini's original accumulator) is exhausted.

The course was absolutely without fever; highest temperature 37.2 C. Patient is able to urinate in the next few days amounting from a few drops to at most 7 c.c.m. spontaneously.

May 25, 1897. (6 days after the first.) Second Bottini operation, with empty bladder. Same instruments as in first. The accumulator is, as a trial, charged with Gülscher's Thermo columns, but as was afterwards ascertained, not sufficiently. Three incisions: one c.m. long posteriorly, one 1.5 c.m. anteriorly, the third 2 c.m. to the right. The knife was again bent and the accumulator almost discharged.

A few hours after the operation, the patient evacuates some urine spontaneously, amounting to about a tablespoonful. In the evening the catheter can not be introduced, therefore capillary puncture above the symphysis and aspiration of the contents of the bladder was resorted to. Four hours later an elastic Mercier catheter is passed, which remains as a retain-

ing catheter. Temperature in the evening 37.9 C., the next morning 38.1; in the evening of the third day 37.6, otherwise entirely normal. Urotropin; also strychnia pills, t. i. d. increased to 0.04 gramme.

May 29th noon. The retaining catheter is removed, following which the patient urinates five times spontaneously, until evening, amounts of from 10–38 c.c.m. In one of these evacuations are found three renal calculi about the size of a pinhead; the patient was never aware of having them, (31st of May when lavaging the bladder some renal gravel was also found). In the next days the amounts spontaneously micturated amount to as much as 84 c.c.m. Regular, sometimes difficult catheterization. Residual urine between 196 and 298 c.c.m.

June 12th. The spontaneous discharges of urine have markedly increased up to 200, at one time even to 300 c.c.m. per micturition.

July 2d. The quite frequent micturition (16–22 times in 24 hours) noted in the early period after the operation, has been reduced to 6–7 times in 24 hours. Catheterization 2 times daily.

July 27th. Residual urine between 170 and 315 c.c.m. Patient now has frequent vertigo and confused sensations of the head, probably due the strychnia pills which he has been taking since the operation, over 2 months, in doses amounting to 0.04 grammes 3 times a day.

Aug. 1st. Vertigo quickly disappeared after cessation of use of the pills.

Oct. 30th. (5 months after the operation.) Patient is well satisfied with his condition; again follows his vocation. Has gained 6 lbs. (134 instead of 128 lbs.). Never again had epididymitis. Urine is only very moderately turbid, smells slightly. Increase of micturition to 8–12 times in 24 hours. Still catheterizes twice a day. Residual urine lately again somewhat increased, averaging from 215–247 and 261–288 c.c.m., therefore:

Nov. 3, 1897. (5⅓ months after the second.) Third Bottini

operation with empty bladder, this time with my incisor, which has been constructed in the meanwhile, and my accumulator and amperemeter. Operation flawless. Three incisions, one each 3.5 c.m. posteriorly, to the right, and to the left. In the afternoon severe pains in the whole abdomen lasting about 3 hours, especially at a point located on the left side, and 1 c.m. superior to, and 2 c.m. internal to the anterior superior spine; at the same time several attacks of vomiting. The left epididymis is slightly swollen and sensitive; catheter finds residual urine of 170 c.c.m. Temperature in the evening 38.4 C. (101.1 F.)

Nov. 4th. Temperature in morning 36.7; in evening with fairly good condition 38.2. Epididymis already entirely insensitive in the morning. Urine slightly red.

Nov. 5th. Again has severe pain in the abdomen during the night. Morning temperature 39.0; evening 39.1, only 51 c.c.m. residual urine obtained by catheterization. Patient urinates spontaneously in abundant quantities and in great intervals, 6 times in 24 hours. Severe pains in the abdomen also during the afternoon.

Nov. 6th. Temperature, morning, 38.1; noon, 38.8; evening, 37.8. Headache and pain in the back.

Nov. 7th. Temperature, morning, 37.7; evening, 38.4. Condition improved.

Nov. 8th. Temperature, morning, 36.7; evening, 37.1. General condition very good.

Nov. 9th. Temperature, morning, 36.7; afternoon, 37.2. Leaves the clinic.

Nov. 13th. Excellent condition. Micturates "like a well person." "Cannot possibly be better."

Nov. 27th. Catheter is introduced (first time since Nov. 5th) for a trial, and 42 c.c.m. residual urine is evacuated.

Further Course.—General condition remains excellent. Micturition accomplished without difficulty with a powerful stream from 4-6 times, usually 5 times in 24 hours, while quantities up to 580 c.c.m. (the latter after drinking beer) are evacuated at one time. Sleeps at night without getting up.

The urine by means of internal medication and occasional (4–5 times) lavage of the bladder, with argentum injections is, since middle of March, 1898, constantly as clear as crystal.

Epididymitis returns but once in a mild way Oct. 15, 1898, following catheterization, performed to determine the residual urine on Oct. 13th.

Patient gains 22 lbs. in weight by middle of February, '99, (150 instead of 128 lbs.) and retains this increase of weight permanently.

Residual urine was determined: Feb. 10, 1898, 20 c.c.m.; Feb. 12, 1898, 58 c.c.m.; Feb. 15, 1898, 23 c.c.m.; March 11, 1898, 41 c.c.m.; Oct. 13, '98, 28 c.c.m.; Nov. 10, '99, 18 c.c.m.; April 14, 1900, 13 c.c.m.; March 13, 1900, (3⅓ years after the last operation) 26 c.c.m.

Last report March 13, 1901 (over 3⅓ years after the last operation). Condition absolutely unchanged in excellence; never again obliged to use catheter; never again had epididymitis. Micturates usually 5 times, rarely 6 times in 24 hours. Sleeps through the night. Urine entirely clear. Weight, 150 lbs.; residual urine, 26 c.c.m.

Case III. Incomplete retention of urine with very large amount of residual urine. Operation with the cystoscopic prostatic incisor, after Freudenberg-Bierhoff. Cure.

H. B., tailor, æt. 69. Bladder troubles for the past 4 years; since 4–5 months markedly aggravated; since 4–5 weeks always mixture of blood on micturition. Urinates now during the day every 2 hours, with pain in the urethra; evenings 1 to 3 times. During the past months has had marked emaciation of the body, excessive thirst, lack of appetite.

On first examination, March 18, 1900, the upper border of the bladder could be palpated close beneath the umbilicus. The prostate gland per rectum was the size of a small lemon, of moderate consistency, smooth, somewhat strongly protruding into the rectum. Urine, color of washings of meat; moderately turbid. Albumin varies (Esbach) between 0.5 to 1.6%. With regular catheterization and lavage of the bladder once a day, later on twice a day, during the next 5 weeks, introduc-

tion of Beniqué sounds to No. 28 French scale, as well as salol and urotropin internally, the residual urine varies from 325 to 655 c.c.m., the average for 10 days amounting to:

From March	19 to 28,	573.4 c.c.m.
" "	29 to April 7,	466.0 c.c.m.
" April	8 to " 17,	524.5 c.c.m.

The urine flows from the catheter during catheterization without projection, finally fairly strong pressure must be applied above the symphysis in order to evacuate the bladder (marked atony of the bladder).

April 3, 1900. Cystoscopy. The mucous membrane of the bladder is markedly red at all points; in spots it is covered with white purulent foci; immense trabeculated bladder, with very marked indentations between the muscle layers. Marked barrier-like hyperplasia of the prostate gland posteriorly; quite marked protrusion to the right anteriorly; to the left but slight bulging is noted, while anteriorly was found a broad notch of irregular contour.

April 24, 1900. Operation with the cystoscopic incisor (Freudenberg-Bierhoff), with eucaine, antipyrine, āā 2.0 aqua d. ad. 50.0; with the bladder filled with about 250 c.c.m. solution of boracic acid. But slightly painful. Two incisions; one posteriorly 3.5 c.m. in length, one to the right anteriorly 2.5 c.m. in length.

Patient is able to micturate at once after operation, discharging 155 c.c.m. of the injection. Moderate hemorrhage. Retaining catheter applied.

Further course: on the 2d day after the operation (April 26th) with mild chill and sensation of heat (no genuine chill) there is increase of temperature by fits and starts to 38.8 which again rapidly declines. Evening temperature next day, 37.6; otherwise never over 37.4. The urine after 24 hours is free from blood, macroscopically. Retaining catheter removed after 3 days (April 27th). The patient is able to immediately evacuate an injected solution of boracic acid, with a good stream. Catheterization now unnecessary. Frequency of micturition in the next days, 10, 9, 7, 6, 5 times in 24 hours.

First examination of the residual urine, May 2, shows 310 c.c.m.; on the 3d, 197; 4th, 98; 5th, 55; 7th, 41; 9th, 57; 11th, 50; 14th, 40; 17th, 28; 21st, 21; 26th, 24; 31st, 29; 13th June, 33; 20th, 33; 29th, 41; 2d July, 24; 7th, 9; 13th, 23; 16th, 17; 20th, 17; 7th Sept., 43; 9th Oct., 31; 24th Mar., 1901, 66 c.c.m.

The patient urinates at the beginning 3–5 times, rarely 6 times in 24 hours, without any difficulty; gains about 6 lbs. in 12 weeks. The urine becomes entirely clear during the course of 5 months.

Last report: Mar. 24, 1901 (11 months after the operation). Never been again obliged to use catheter. Urinates for the past months only 3 times in 24 hours; without difficulty—sleeps through the night; weighs, although passing through a severe attack of pneumonia in the meantime, 8 lbs. more than before the operation. Urine entirely clear. Residual urine 66 c.c.m.

Case IV. Complete retention of urine. Unsuccessful prostatotomia perinæalis. Cured by Bottini's operation.

G. N., Russian merchant, æt. 49. Referred to me for operation by Geheimrat Prof. v. Bergmann and Dr. Borchardt.

June, 1899, following facial erysipelas, had acute retention of urine, having had previously for a long time suffered from difficult micturition and frequent urging after catheterization. Retention of urine ceases after 6–7 days, to re-appear after a further relapse of 8 days and remain constant since then. Some time subsequent an abscess of the prostate gland develops which perforates the urethra and rectum. As this proved not amenable to treatment, Geheimrat v. Bergmann incised the abscess cavity on Dec. 5, 1899, from the perinæum. The complete retention of urine remained unchanged. For this reason, beginning of March, 1900, the perinæum was again laid open and the prostate gland was incised along its entire length posteriorly to the bladder. Even after this procedure, the retention of urine remained entirely unchanged. After kindly turning over the patient to me, he was first seen May 1, 1900.

Status.—Fairly vigorous man. Perinæal fistula and fistulous

contraction in the rectum, close above the sphincter. The prostate gland can be felt to the left of the rectum rather diminished, to the right but slightly enlarged.

Cystoscopy: Trabeculated bladder. Hyperplastic bulging of the prostate gland projecting only on both sides into the bladder; anteriorly between these was a broad cut. Posteriorly no bulging at all was determined.

May 7, 1900. Bottini operation with bladder filled with air, with the Freudenberg incisor, with chloroform anæsthesia, by request of the patient. Four incisions, one each to the left and left anteriorly of 3 c.m.; one each to the right and right anteriorly of 1.5 c.m. No incisions were made anteriorly or posteriorly. After completion of the operation 250 c.c.m. boracic acid solution is injected into the bladder, ⅔ of which is evacuated with a strong stream by the patient, while still in a semi-narcotic condition and resting on the operating table, as soon as the catheter was removed.

On the following day he had chills, catheter fever to 40° C., and the following days until May 14th, increase in temperature between 37.5 and 39.0; but catheterization for evacuating the urine is unnecessary immediately after the operation, as patient is able to micturate with a good stream. General examinations of residual urine show none or but few drops of residuum. On micturition small quantities of urine are also discharged from the perinæum through the rectal fistula. Patient leaves for home on May 20th.

Status—March 29, 1901. (10⅔ months after the operation.) General condition excellent. Has never again used the catheter. Can hold the urine usually from 3–4 hours; when he is busy, however, or sleeps quietly at night can hold it from 6–7 hours. Micturates with a very good stream. Residual urine barely 2 c.c.m.; urine clear. The only complaint which the patient still has, is the fact that small amounts of urine are discharged from the rectal fistula (possibly also from the perinæal fistula) during micturition, so that he is usually compelled, in order not to soil the underwear, to seek the closet. An attempt will be made to close

the fistulæ by means of the retaining catheter and vigorous cauterization.

Case V. Complete retention of urine for the past 28 years. Cured by means of the Bottini operation.

V. D. A. (retired), æt. 82, operated at the University Surgical Clinic. Referred to me for operation by Geheimrat Professor v. Bergmann and Dr. Reich of the staff.

Received at the clinic Feb. 3, 1901.

In the summer of 1873 had acute, complete retention of urine, which immediately became constant. Urine at that time is already said to have been turbid. In the 28 years elapsed since that time, patient discharged urine in a natural way, but on one night, some 7 years ago, after he had imbibed on that evening ½ bottle of champagne and could not introduce the catheter owing to lack of lubricating fluid (clearly therefore no true spontaneous micturition, but rather incontinentia paradoxa). At the beginning, the catheter was introduced 3–4 times in 24 hours, gradually increasing in number. Since 7 weeks patient is obliged to use the catheter every 2 hours at night, and every 2–3 hours during the day, causing intolerable pain in the perinæum, along the urethra and in the glans. Strong ammoniacal cystitis. Variations of fever to 38.0 C. After 5 weeks' treatment with internal remedies (urotropin, acid camphoric, etc.) as well as regular lavage, retaining catheter, later on iodoform injections, the temperature becomes normal, the urine is markedly improved; catheterization is also required less frequently, so that intervals of 5 hours take place. Complete retention of urine remains unchanged. As sequelæ to the iodoform injections mild hallucinations and mental irritation supervene (iodoform intoxication) so that the remedy must be discontinued.

Feb. 16, 1901. Cystoscopy. The bladder holds but 120 c.c.m., bladder wall markedly reddened; trabecular bladder. The prostate gland shows bulgings on both sides and posteriorly. Moderate notch anteriorly. Per rectum: The prostate gland is the size of a lemon, markedly protruding, hard in consistency.

Mar. 9, 1901. Bottini operation, with my incisor, with chloroform anæsthesia, and the bladder filled with air. 3 incisions one posteriorly 4.5 c.m., one each to the right and left of 4.0 c.m. Hemorrhage almost nil. Of the boracic acid solution injected after the operation, the patient is able to squeeze out a few drops immediately after the operation. Retaining catheter.

Temperature course flawless—highest temperature 37.2 C.

Mar. 13th. Patient who is again somewhat excited and suffering from hallucinations (probable after-effect of the iodoform, which, however, had been last injected Mar. 6th) tears out the retaining catheter during the night, although same had acted well to date.

The catheter is therefore left out during the day, but is again introduced for the following 10 nights.

Mar. 14th. Patient is again entirely rational. He discharges very small amounts of urine spontaneously.

In forenoon and evening residual urine of 170 for each time, is determined.

In the next days the ability to urinate spontaneously again ceases (reactive tumefaction).

General condition continues good.

First on the evening of 21st March (13th day after the operation) co-incident with an abundant discharge of the slough, the patient again commences to urinate with a small stream. The quantities of urine discharged spontaneously are now rapidly increased. On the 22d during the course of the day 200 c.c.m. are spontaneously discharged; on the 23d 250 c.c.m. In the next days a still further increase is noted, so that catheterization is necessary only in the morning and evening.

Mar. 25th. Patient leaves the clinic in good general health with the instruction to perform lavage for the present in the morning and evening.

Residual urine at noon. 75 c.c.m.

Report by letter, Mar. 29. (20 days after the operation.) Describes his condition as normal. "The urine flows very

abundantly." Still has an unpleasant sensation of pressure in the region of the bladder at the cessation of micturition.

Status.—April 13th. (35 days after the operation.) Urinates with a good stream every 4 hours; requires no catheter, excepting for lavage of the bladder. Urine is still moderately catarrhal.

Examination of the residual urine at noon shows merely 15 c.c.m. The bladder holds 240 c.c.m. during lavage.

SECTION SEVEN.

Diseases of the Nose and Throat.

The galvano-cautery has long been used by throat specialists for the purpose of removing growths, but of late the galvanic and even the faradic current has been used for stimulating properties, and also in the case of the galvanic current for the electrolytic effect.

Hypertrophy of the Nasal Mucous Membrane.—The galvano-cautery has been used for the removal of hypertrophies of the Schneiderian membrane over the turbinated bones. It is certainly a most effective and simple method of treatment. After the application of cocaine, the cautery knife may be applied so that the flat surface comes well against the membrane. By means of the connector in the handle, sufficient current is turned on to produce a very dull red heat. It is important that the heat should never reach great intensity. This is easily accomplished by breaking the current when the heat rises above what is wanted. After the heat falls below an effective point the current is again made.

The contraction following the application of the galvano-cautery always depends upon the degree of heat used. The less the heat, the more contraction, and with a white heat scarcely any contraction takes place. It is very desirable here to get contraction rather than destruction of the tissue. There is not so much danger of atrophy supervening. The operation should not be repeated for at least one week, and even a lapse of two weeks is better. Wait until the membrane is healed and contraction has taken place. If this rule is fol-

lowed there will not be much danger of exposing the bone from over-treatment.

Electrolysis has for some time been used for the removal of these growths. In one case of an exceedingly strumous diathesis, in which we removed the growth with a galvano-cautery, and which returned within two years, electrolysis was used with very permanent results. The method employed was to use the negative pole only in the growths, puncturing them with a small needle, while the positive pole was attached to a large electrode and placed over the back. To accomplish the destruction of a tumor by electrolysis requires many more treatments than by the galvano-cautery, but the application can be quite painless, and therefore the number of operations is not so material. Scheppegrell, to whose work we refer all readers who desire an extensive treatise on the use of electricity in the nose and throat, as well as the ear, uses a double electrode by which means both poles are introduced into the growth at the same time. This is a much simpler and quicker mode of treatment, and has the advantage of securing the contractile effect of the positive pole along with the greater destructive properties of the negative. Of course, the needle which is attached to the positive pole, should be made of platinum. In this case there need be no soreness following the treatment unless it be carried too far. In angiomata, electrolysis seems to offer the least danger to hemorrhage.

Metallic electrolysis, which is performed by introducing a zinc or copper needle into the growth and attaching it to the positive pole allowing a current of 10 milliamperes to pass for five minutes, has been highly extolled.

Spurs, Deviations and Malformations of Septum Nasi.—Bipolar electrolysis has been employed with much success for the removal of spurs and the correction of deviations and malformations of the septum nasi. The parts are asepticized and some local anæsthetic applied, preferably cocaine or eucaine. The surrounding mucous membrane is protected from injury by strips of rubber. The needles, when operating on the

septum should always be introduced parallel to the septum so as to prevent perforation, and a current strength of from 20 to 50 ma. employed for one to two minutes.

Polypi.—The electro-cautery ecraseur is much in favor for the removal of polypi. The method of using it is apparent to every physician and need not be described in detail here. There seems to be some objection to it in the removal of polypi well back in the pharynx. This is due to the fact that the platinum wire used for this purpose cannot be made sufficiently rigid, and it is difficult to get it over the polypi, while the steel wire of the cold ecraseur will retain its shape and can be easily hooked over the growth. There has lately been constructed by Vulpius an ecraseur to be used with the cautery, which does much to overcome the difficulty. It consists of two rigid brass arms connected by a platinum loop at the end. This loop can easily be hooked over the polypus and brought to a dull red heat, when it will adhere to the pedicle. More heat is then turned on and the instrument gradually withdrawn, when it will cut its way through, severing the pedicle.

The advantage of the cautery operation is that it is bloodless, or much less so than that with the cold ecraseur, while the probabilities of return are not so great. In connection with Dr. J. M. Schley, we once removed a portion of a fibrous growth as large, or nearly as large, as a hen's egg, from the posterior wall of the pharynx, with the galvanic-cautery ecraseur and with comparatively little hemorrhage. The patient made a rapid recovery and the remainder of the growth was afterward successfully removed in the same way by Dr. Irving Townsend. The electro-cautery is especially beneficial in cases of this kind, as these growths have such a tendency to hemorrhage. Then, too, the soft, pliable platinum loop has the advantage that by introducing the finger into the pharynx, it can be easily placed around the tumor. Electrolysis has also been recommended here, but it is very difficult to perform and may be somewhat dangerous. It is apt to produce vertigo

and other symptoms of cerebral disturbance, as the current used to destroy fibrous growths must be considerable.

Ozœna.—Cupric electrolysis, largely owing to its antiseptic properties, has been preferred and used to advantage in this affection. Rettri of Vienna and others have employed electrolysis in the treatment of ozæna with considerable success, their experiences showing that while chronic cases, which have gone on to destruction of tissue, cannot be completely cured, they may be much improved, while cases of recent origin, generally yield readily to appropriate treatment. In view of the fact, that other methods of treatment offer but scant amelioration, electrolysis should be accorded due trial in these distressing conditions. The technic is as follows: After carefully cleansing the parts, the area to be treated is anesthesized with eucaine or cocaine. A copper needle attached to the positive pole is then introduced into the mucous membrane to be treated and a steel needle is placed somewhat beneath it on the same side so that the current traverses a given area at each puncture. The current strength should vary from 15 to 30 ma. according to tolerance, and treatment should consume from 10 to 15 minutes. The needles are then re-introduced at other points until a number of punctures, fairly covering the affected area, have been made. Small strips of rubber may be placed in the parts of nasal cavity not being treated, to prevent injury to the mucous membrane. Usually two seances, about a week apart, suffice to affect a cure. In recent cases the mucous membrane rapidly becomes normal, while chronic cases although usually improved, sometimes show more or less atrophic change.

Removal of Enlarged Tonsils.—In the removal of enlarged tonsils the only advantage in using the galvano-cautery ecraseur instead of the cold ecraseur is the less liability to hemorrhage. This, however, is but slight unless the patient be subject to a hemorrhagic tendency, when, of course, it is very important.

Puncturing the crypts of the tonsils by a pointed galvano-cautery knife seems superior to the other method. It renders the tonsil less liable to germ infection as there is no exposed

denuded surface, and for this reason, particularly, should have preference over the ecraseur. It is not our purpose to make comparisons as to methods, but to leave that to the physician. We have seen some of the most startling results from puncturing enlarged tonsils with the galvano-cautery knife. It must be admitted, however, that all cases do not respond with equal readiness; but with persistency and painstaking care to have the knife fit the crypts of the tonsils snugly, any tonsil may be reduced, and without any special soreness or inconvenience. A galvano-cautery knife bent at a right angle with the shaft is embedded into the crypts of the tonsils. The current is then turned on by means of a connector in the handle. Smoke and fumes will immediately issue from the crypts, when the knife should be removed and inserted into another, care being taken not to burn the crypts too closely together as in such case a large slough will form. Success will be better if this is avoided, for then scarcely any sloughing takes place, and there is very little soreness. A markedly enlarged tonsil may be punctured five or six times at a sitting, but small ones not more than two or three times. The patient should then be allowed to rest for one week, when it will be found that the tonsil has shrunken very much, and the treatment may be repeated. If rightly done, and the knife is thoroughly inserted before the heat is turned on, the operation is generally painless. This is not universally true, however, but it is very rare that the operation is painful to any degree. In fact, we have many times operated on children under six years of age, and after getting them accustomed to the treatment, have had no trouble in repeating it. Electrolysis has also been used for enlarged tonsils, but after considerable experience, we believe it is very inferior to the cautery; that has at least been our experience. If it is applied, the same procedure as for hypertrophy of the Schneiderian membrane should be employed.

Diseases of the Pharynx.— The use of electricity has been recommended for catarrhal conditions of the pharynx, as well as other inflammatory conditions, but its benefits are de-

cidedly problematical. One method is to insert the face into a basin of water, allowing the water to run into the mouth and nose, and using this as a fluid conductor for one pole of the battery. Another method is to spray the throat or syringe it with a post-nasal syringe, using the fluid injected as a conductor. Some years ago we had considerable experience with this method of treatment; but the success did not warrant continuance of it. However, there are those in the medical profession who claim great results from it. Others have recommended metallic electrolysis, placing the stick of copper against the inflamed surface, to which is attached the positive pole, and getting a slight electro-cupric effect.

Paralysis of the Pharynx.—Not only is electricity used in many cases of paralysis of the pharynx, but it is useful as a diagnostic agent. If reaction of degeneration is present, we know the paralysis is due to some nerve lesion. If it is not present, it is central of origin. The method of producing contraction of the pharyngeal muscles is to press a small electrode well in between the angle of the jaw and the anterior border of the sterno-mastoid muscle. By using a current of sufficient strength, the interrupted galvanic current negative pole will produce contraction of the pharyngeal muscles, causing the soft palate to rise and the constrictor muscles to come forward. By having the patient open the mouth well, depressing the tongue, these contractions can be easily seen. The rules and prognosis governing paralysis in other parts apply here. A good method of treating these cases, is to cause more or less vigorous contractions, according to the weakness of the muscles, from each side of the neck, care being taken not to tire them. Sajous uses water as a conductor and gives the following directions for its use:

"The patient having taken what is usually called a mouthful of water, in reality about an ounce, he is told to throw his head backward and open his mouth. The first movement of deglutition causes the water to fill the pharyngeal cavity. Light being thrown in, a Mackenzie electrode is introduced and simply immersed in the water, the external electrode,

thoroughly wetted to secure penetration through the skin, being placed over the thyroid region. The current being then closed by pressing the button of the electrode, it is allowed to flow as long as the patient can hold his breath. The mouth electrode being then taken out, he can either by closing his mouth and bowing his head forward bring the water forward and take a few breaths through the nose, then renew the first movement, throwing the head backward, etc., or take another mouthful of water, after ridding himself of the first draught."

This treatment undoubtedly has a very good effect upon the pharynx and may be used with success in many cases even in pharyngeal catarrh.

Diseases of the Larynx.—Electricity has been recommended for removing nodes of the vocal cords. We once removed a node in a woman, forty-five years of age, very successfully. The instrument was made of an ordinary catheter bent in such a shape that the point could be easily brought in contact with the node, something like the ordinary brush made for operating on the vocal cords. The ends having been removed a shaft was placed inside the catheter with a needle at its farther extremity. The catheter was placed down upon the node, and with a little pressure the needle was thrust out and into the structure of the node. Electrolysis was performed some two or three times, when it was found that the vocal cords were left entirely clear. The amount of electrolysis was very slight, just enough so that a few bubbles of hydrogen were set free. This operation was performed in conjunction with Dr. Malcolm Leal and should never be undertaken except when the patient is in the hands of an expert laryngologist.

Electricity is successfully used in paralysis or weakness of various muscles of the larynx. Here again electro-diagnosis may help to locate the seat of the paralysis, if such exists, but it must be admitted that this is a very difficult undertaking and requires the best of technic. By placing the electrode over the motor point, and with the laryngeal mirror in position to see the vocal cords, contractions of some of the muscles may be noticed, especially those which bring together the pos-

terior ends of the vocal cords. The best method of treating these cases is to use the interrupted galvanic current. There is no method, according to our firm belief, of increasing the nutrition of muscles, and improving their power and strength, equal to the active exercise of those muscles by the galvanic current. We not only get here the active exercise, but the catalytic and nutritive effect as well.

As all the different functions of the vocal cords are controlled by muscles, it is evident that we must rely on the strength of these muscles, their quickness of reaction, and power of endurance to give both quality and power to the voice. The crico-thyroid muscles by their contraction, force the anterior attachment of the vocal cords downward and forward and thus tense and elongate them. The arytenoideus, and crico-arytenoidei laterales close them. The first set of muscles, or crico-thyroid, is supplied by the superior laryngeal, while the two latter groups are supplied by the inferior or recurrent laryngeal nerve.

In order to apply the interrupted galvanic current to these muscles, we must first have motor points. It is impossible to find these points inside the larynx, and even if that were practicable, the galvanic current could not be given to them with impunity. We must therefore look for them on the outer surface. After carefully studying the anatomy and experimenting with electrodes of different sizes and shapes we have succeeded in locating these points. (See section on motor points.

We have reported a number of cases in which singers who have lost their voices from weakness of muscles, and in some cases, from an unequal strength of the muscles of the two sides of the larynx, have been completely cured by vigorous contractions through this point. It is quite possible to assist very much in the development of the higher vocal register by this means. The same principle applies in treating paralysis here, if it exists, as in paralysis of other parts of the body. This treatment has always been found very effective in the curing of a chronic, passive congestion of the larynx,

where the membrane surrounding the vocal cords has become congested, loading them down, as it were, and producing hoarseness.

Laryngeal Stricture.—Boulay of Paris and Boulay of Rennes report an interesting case of laryngeal stricture. A young man, 19 years old, tracheotomized at 3 years of age for a malady that presented all the characteristics of prolonged croup, had never been able to have the canula removed. He presented a glottic and subglottic stricture,—leaving only a narrow passage for the air—which neither forcible dilatation, prolonged slow dilatation, galvano-cautery nor ecraseur had succeeded in modifying. Repeated seances of intra-laryngeal electrolysis created in a few months a passage sufficiently large for the canula to be taken away without trouble, and, what is better still, to the great benefit of the patient, whose general condition has considerably improved.

Goitre.—In order to understand the electrical treatment of goitre it is necessary to glance at the different pathological forms in which it manifests itself. It is generally divided into parenchymatous, cystic, fibrous, calcareous, and amyloid. With the fibrous variety little can be done; and it is only amenable to the puncture treatment. The parenchymatous variety is, as a rule, amenable to the cataphoric treatment. All methods, or nearly all, at least, are based upon the use of iodine either in an internal administration, or, more commonly, in local application.

In electricity we not only have the absorbent and catalytic effect of the galvanic current, but at the same time this current is capable of carrying iodine into the very substance of the goitre; and, as this iodine is carried in molecule by molecule, it exerts upon the goitre a far greater action even than when injected in mass, and a very much greater effect than when applied to the surface. The method of application is by saturating a piece of cotton or gauze—in fact any material which will absorb the iodine—and placing this upon a metal electrode, preferably a catalytic electrode, to which is attached the negative pole, the positive being placed upon the back of

the neck or between the shoulders. It is possible, if a current be continued long enough and with sufficient strength, to carry all the iodine into the tumor. Treatments may be given two or three times a week, ranging from five to ten minutes, not using less than five ma., and ten should be the goal sought.

We have invariably cured the small goitres which have been only of short duration in their growth. In young girls it is marvelous how goitres of this type disappear under this treatment. As the goitre grows older and becomes more fibrous by an increase of the connective tissues, the treatment is not so effective. Here we must produce electrolysis, and even that treatment is not so successful as we might wish. A small needle thoroughly insulated is introduced into the tumor and the negative pole attached to it; or, if the tumor is moderately soft the positive pole may be attached to an iridium-plantium needle and both poles may be introduced into it, of course attaching the positive pole to the platinum needle. Ten or fifteen ma. may be passed for a period not to exceed five minutes. If after a few treatments the tumor does not show a decided tendency to contraction, it is useless to continue it longer.

The cystic variety does not seem to yield readily to either of these forms of treatment. A successful method of treating this variety is to draw off part of the fluid by means of a trocar and through the canula inject a saline solution. A probe insulated except at its extremity, is passed through the canula so that there is no electrical connection between the two instruments, and is connected to the positive pole of the galvanic battery. It is thought by some that the chlorine set free in the formation of the hypo-chloride, which must take place by electrolysis of the saline solution, acts on the wall of the cyst, destroying its secretive powers. This, however, can hardly be the case, as the great affinity existing between chlorine and hydrogen makes it more probable that the hydrogen of the watery contents of the cyst forms a combine with the chlorine, leaving a nascent oxygen to exert its great power upon the wall. This treatment is often successful, but probably less so

than by injecting a two drachm ten per cent. solution of iodine, and introducing the negative pole in the same way, setting free the iodine molecule by molecule, and by its catalytic properties dispersing it in all directions, not only into the secretive membrane alone, but into the entire mass of the tumor. This is a very successful method of treating cystic goitre.

SECTION EIGHT.

Diseases of the Skin.

A new and wide field is about to open for the use of electricity in diseases of the skin. The static has shown evidences of what the higher potential charges may do, but it has not been sufficiently successful to lead one to predict any great prospects for it in the future. The high frequency current, however, which is just coming into use, is showing evidences of great power in relieving many of the heretofore intractable skin diseases. Already a few cases of eczema have been reported cured by it. A few physiological experiments will demonstrate the power of this current to increase the circulation of the blood through the skin, and consequently increase the nutrition. Unfortunately just at present no definite rules can be given for treatment based upon experience, nor can there be any special indications given for its use. The apparently germicidal action of the X ray and static charges also afford an efficient means for the cure of tinea tonsurans, favus, sycosis and other diseases depending on the presence of local micro-organisms.

Removal of Hairs.—In order to fully understand the process of destroying the hair growth by the electric current, it is necessary that we should understand the formation of the hair follicles and the action of the current upon them. An ordinary depilatory applied to the surface will loosen the hair, so that it can be removed with the same ease that it can when operated on by the electric needle; but it will immediately return, larger and stronger than before. It is, therefore, evi-

dent that the killing of the hair does not permanently remove it, but that the part of the follicle which forms the hair must be destroyed.

The hair follicle is lined with three layers of cells;—an internal one, which is a homogeneous structure, similar to the transparent membrane formed between the rete Malpighii and the corium; the middle layer consisting of connective tissue, with its oval nuclei imbedded into a granular substance; and the external layer which is fibrous, and contains most of the blood vessels and nerves of the follicle. It is claimed by some that the inner layer furnishes the nutrition, the second or middle layer the cells and papilla, and the external the pigment or coloring matter for the hair. Others differ slightly from this view, but all agree that the middle layer is absolutely essential to the formation and growth of the hair. It is, therefore, necessary, in causing the destruction of hair growth, to destroy this middle layer of cells.

If an alkali of composition similar to that set free by the negative pole, could be introduced into the hair follicle and held in position, the action would be the same as the polar action of the current. This fact having been recognized, there has arisen a method of destroying hairs by carrying into the follicle a solution of caustic potash; but the difficulty of carrying the solution to the depth of the follicle and the inability always to control action, thus at times causing destruction of tissue which was not intended to be destroyed, has made the method unpopular.

The paraphernalia needed are a galvanic battery capable of giving off eight to twelve volts, and in which the voltage is comparatively large per cell, such as the red acid or Leclanche cell, since that will be less painful than if the cells used are of small voltage; a flexible hand electrode, a pair of epilation forceps, and a needle with handle to hold it on. The two latter need special mention. The handle should be solid, that is, not containing an interrupter, as was formerly used and is recommended by some to-day; for the shock caused by closing the circuit after the needle is inserted not only gives more

pain, but also produces bad effects on the nervous system of susceptible patients.

Various needles have been recommended by different operators. The one which we prefer above all others is what is known as a jeweler's broach. These possess one recommendation which no others have, and that is cheapness, for they sell for about fifty cents a dozen; the platinum and gold needles are very expensive, more cumbersome, possess no advantage over the broach, and in many respects are not as good, for the very thin ones are so pliable that they are useless. After selecting a few broaches, varying in size, as is necessary in operating on small or large follicles, the sharp point should be removed and the rough square surface rounded down to a blunt point, the work of a few minutes only on an ordinary oilstone. This is the only preparation needed.

The bulbous point recommended by some is not necessary, nor is it necessary to draw the temper, for one who has not the steadiness of hand to introduce the needle as it is, without the slightest danger of breaking it, had best leave the operation alone. But we wish to emphasize the importance of having the needle blunt-pointed. A sharp-pointed instrument would glide through the side of the follicle so easily that it would not be perceptible to the operator, whereas the blunt-pointed instrument would follow the hair, the walls acting as a guide for it also. When it has reached the bottom of the sac it will stop and some little effort will be required to push it beyond this point. The sharp-pointed instrument would penetrate the bottom of the sac without the perception of the operator, and thus electrolysis would be produced in tissue, which is not only unnecessary, but is injurious.

The Technic of the Operation.—The flexible hand electrode is well moistened and placed in the patient's hand, or on some convenient part of the body. If the patient is particularly sensitive, it may be laid in some convenient place, and after the needle is introduced, the patient gradually puts her hand on to it. First the tips of the fingers, and gradually the whole palm of the hand is brought down on it; when the process of elec-

trolysis has been carried far enough, she can as gradually raise her hand, thus avoiding the disagreeableness of the slight shocks that occur on introducing and withdrawing the needle, which are really cathodal closings and openings. This, however, all takes time, and it is only necessary with particularly sensitive individuals, for, with the majority of cases, there is no complaint, after the first few hairs have been removed. The needle is introduced down alongside the hair to the bottom of the sac and no further. This introduction of the needle is the all-important part, so far as the success of the operation is concerned, and the experienced operator will depend more on the sense of feeling than on sight. If the needle is in the follicle, it glides smoothly along with but very little pressure until it reaches the bottom; but, if it should not enter the follicle, considerable pressure will be required to make it go through the epidermis, when it will suddenly slip further in, accompanied usually by a light crackling noise.

The amount of current required depends upon the amount of resistance in the circuit. If the surface electrode is held in the palm, four to six Leclanche cells may be needed; if it is placed on the back or chest, not quite so many will be required, as the resistance will be less; but from two to four milliamperes should be used. The ordinary ma. meter cannot be used as a reliable guide, for it is not generally correct enough on such small measurements. An instrument which would be absolutely correct on large measurements might, from a lack of sensitiveness, fail here. In ascertaining the strength of the current required, one rule should always be followed: begin with the minimum amount and gradually work up to the strength required. If you should unduly shock your patient at the start, you are apt to destroy her confidence and get her into such a nervous state that the operation will be much more difficult.

The length of time the needle should be left in the follicle varies with the strength of current used and the amount of moisture in the follicle. The greater the strength and the greater the moisture, the shorter will be the period. Usually

from one-half to three-quarters of a minute will suffice. A little white foam will usually be seen around the needle. Unless the electrolysis is carried too far there is no peculiar appearance of the hair or the surrounding tissue to indicate that it is time to withdraw the electrode; but experience will soon teach one to gauge it correctly. After the needle is withdrawn, the hair should be removed with a pair of small forceps. If it comes out easily, the follicle is sufficiently destroyed and the hair will not return; but, if some force is required to remove it, the hair is not dead, so to speak, and the needle should be reintroduced and the current applied again.

Regarding the pain from the operation, we would say that we have never had a patient abandon treatment on that account, although some have apparently suffered much from it, while others do not mind it in the least. The pain differs according to the degree of sensitiveness of the patient. The ointments containing cocaine and menthol which have been recommended as local anæsthetics are useless, and the same can be said of the ether spray. The hypodermic injection of cocaine relieves the pain in a small area for from ten to fifteen minutes, but it is only practical for those cases where a few hairs are to be removed from a small space, such as a hairy mole. The same is true of cocaine used cataphorically. If the operator is careful, taking plenty of time, he will not have much trouble in getting the patient to bear all the pain necessary.

Some patients are so constituted that the electric current produces very bad effects on them. It is due to some idiosyncrasy, and is not only noticeable in this, but in all forms of electrical treatment. In such a case the sittings should be of short duration, a very weak current should be used, and the positive electrode should be placed on the chest or back, as close to the face as is practicable, so that there is as little electricity distributed through the system as possible.

As the object in removing the hair is to get rid of a disfigurement, it is very essential that we should not cause another disfigurement by the formation of a scar. In order to

successfully remove a hair it is necessary to destroy only a microscopical amount of tissue; consequently the scar tissue is microscopical, and not visible to the naked eye. It sometimes happens that the root of the hair runs in a different direction from what the hair would indicate. In such a case, it is very difficult to introduce the needle into the follicle. The tendency is to reintroduce the needle alongside the hair several times until quite a circle of tissue is destroyed. It is always better to wait and try and remove the hair at some other sitting.

Another cause of scars is the removal of hairs so close together that the destroyed tissue of one follicle runs into that of another. If enough of these should be close together, a large, dark spot will be left, and, consequently, a visible scar remains. This can be easily guarded against by not removing hairs situated closely together. The same principle applies to too frequent operations. Treatments should not be given on the part of the face that has been treated until it has entirely healed, which will take from four days to a week. Of course, if the face has not been entirely gone over in the previous treatment, that part which has not been touched can be treated the next day, if the patient is in a hurry.

Regarding the after-treatment of the operation, we would say that we have tried various things. Now we simply rub a little talcum powder on just after finishing the treatment, and instruct the patient to follow the same course every morning.

Undoubtedly, even with the best operators, hairs will return; but, with due care, this can be reduced to five per cent. and even less.

It is claimed that the electric current stimulates the growth of hairs, and that many more are made to grow by this treatment than would grow if left alone. If the hairs are all large and coarse and not interspersed with a growth of down there need be no fear of any others coming in when the coarse hairs are removed; but when there is a heavy growth of down mixed with the coarse hairs, the tendency is for the downy hairs to slightly increase in length after the coarse ones are

removed. The new hairs are, however, easily removed as the follicles are so shallow, and the fact that the down does slightly increase in length should not in the least deter any one from treating such a case. One thing should be borne in mind, and that is that the treatment takes time, and, unless the patient can come back within the following year to have the few returning hairs removed, she must be made to understand that she will not have a perfectly clean face.

The X ray has been employed by some for the removal and destruction of hair. Dr. Freund especially, claims abundant success in its use, but cautions circumspection in the application.

Where large surfaces are to be denuded—such as are found on the chest or arm—and much down is present, the X ray may be used, but when small surfaces are involved, electrolysis will be employed with more safety and permanence. We would repeat Dr. Freund's caution in regards to the use of the X ray as there have been many terrible results from the use of it for this purpose.

Wrinkles.—Massage with the faradic hand and with the faradic roller have in some cases proven successful in removing wrinkles. The fine coil, the current of tension, is preferable in order to obtain penetration and frequent interruptions are most serviceable.

Nævus Vasculosum.—It is necessary to classify the various forms of nævus under two heads, that is, the elevated and non-elevated, as the two require different forms of treatment. If we should introduce two needles connected with the respective poles into healthy tissue and allow a current to pass strong enough and long enough to produce destruction, and then allow the wounds to heal, we shall find that two scars remain, varying in size according to the amount of tissue destroyed. If we watch these scars for some months, we will find that the one produced by the positive pole very soon turns white, sinks slightly below the surface and contracts until it is a hard, cicatricial spot and looks badly. On examining the scar produced by the negative pole, we find nearly the opposite con-

ditions. It may be elevated above the surface of the skin and is very liable to remain red and irritable. It will, therefore, be seen, that if we get the proper amount of action of the different poles the scar will not be depressed, contracted and unduly white, or elevated, red and irritable.

In removing a nævus, the most important thing is to do the work thoroughly and permanently, and yet leave as little disfigurement as possible. It is here that the proper balancing between the two poles of the battery comes in. Of course, this is always more a matter of judgment than anything else; but a few rules will help very much. First, the temperament of the patient should be our guide. If the patient is plethoric, the action of the positive pole should predominate; and, if thin and anæmic, the negative should. Second, the deep-seated nævus requires the predominance of the positive pole, and the superficial, the negative. Third, we must consider the age of the patient. A young active person requires more of the positive pole than of the negative. Fourth, regarding the character of the tumor. The bright, red, arterial nævus requires the predominance of the positive pole, while a dark, venous one will require the predominance of the negative. Fifth, the location; if the tumor is situated on that part of the face where it is exposed to the cold blasts of air, or subject to irritation of any kind, the positive pole should predominate, for the negative scar is congested by the least irritation.

One point which should be carefully looked after is to see that all the disease around the edges is thoroughly destroyed, leaving nothing but healthy tissue. If any of the nævus tissue is left, that will make the scar much worse, leaving the edges rough and elevated, if indeed it does not even act as a nucleus for the return of the tumor, which is liable. In one case we have seen, the diseased tissue that was overlooked, prevented the growth of the integument over the place, thus leaving an unhealed surface for months. On the other hand, one should be careful not to destroy more tissue than is absolutely necessary, for the scar will be greater.

The needles are introduced at the base of the tumor, paral-

lel to the surface; not under the tumor, but so near the bottom that the electrolytic process will destroy it entirely. The destructive influence of the current is the same on all sides, and so the amount of tissue destroyed underneath the needle can be judged by the amount that is acted on above the needle; hence it becomes very necessary to diagnose the depth of the tumor before introducing the needles. If both needles are to be introduced,—and this will be done unless you should wish to get the action of one of the poles exclusively,—the positive needle which should always be of platinum or gold, should, if possible, be introduced over the orifice of the principal vessel supplying the nævus, for the eschar produced by the positive pole is firmer and it is not liable to be absorbed by the pressure of the circulation, as is the case with the soft, negative eschar.

If the nævus is located where the bone comes near the surface, as for example over the malar bone, great care should be exercised not to set up an inflammation of the periosteum, for, if this is done, the whole surrounding tissue becomes adherent to the periosteum, and a very unsightly scar is left. The after-treatment is very simple. A piece of iodoform gauze may be strapped over the eschar and changed as often as circumstances may require. When the slough comes off, the sore should be kept clean and dressed with iodoform or zinc ointment; if the operation has been thoroughly performed, it will heal rapidly.

One kind of tumor classed as a nævus requires a slightly different method of treatment, and that is where there is a smooth integumentary growth over the plexus of vessels. Here it is necessary to destroy the plexus of vessels without producing a slough. This is a very difficult thing to do. The needles should be so insulated that there is no electrical action around the seat of the puncture in the integument. The needle attached to the positive pole should be of platinum or gold, and of large size. It should be introduced through the center of the tumor and left in that position. The negative needle should be smaller and inserted, first on one side of the

positive, and then on the other. The process should be continued until the whole tumor has a hard, inelastic feel, but no discoloration should take place. It should be carefully watched and if within the first week, there are signs of softening, the operation should be repeated immediately; but, if it remains hard for one week, the disease is generally cured. In some cases there is a great tendency to return, and after several attempts, one may be forced to produce a slough in order to get rid of the disease.

The flat, vascular nævus (port wine mark) is removed in a somewhat different manner. Under this head may be included pigmentary nævi, moth patches, etc. The same principle governing the selection of the respective poles should apply here as in the other form of nævus. Instead of performing electrolysis of the base, we simply puncture the nævs, the punctures being about one-sixteenth of an inch apart, and the electrolytic process is continued until the action around each of the needles coalesces with its nearest neighbor, thus making a continuous patch. It is generally best to introduce the poles alternately—positive, negative, positive, etc. A slight puncture should be made as the electrolytic process is carried on beyond the point of the needle the same as it is around it. Caution regarding the edges of the nævus is just as applicable here as in the treatment of the elevated form, although it is not quite so necessary, as it will not prevent the nævus healing. It is, however, important that the new integument which is to cover the surface should start from healthy borders.

If the nævus is large, several operations may be necessary before the cure is completed, allowing the slight inflammation produced by one operation to heal before another is attempted. The operation is not painful, and can easily be done without an anæsthetic. The method recommended by some to first blister the nævus and produce electrolysis on the surface with a blunt instrument, always leaves a very bad scar, and should never be employed.

Warts, fibrous growths, and moles come under the same

head of elevated vascular nævus, and the rules given under that heading will suffice here. When a mole has hair growing in it, (nævus pilosus), the hairs should first be removed. Then wait for the tissues to heal, when it will generally be found that the mole has been removed also, but, if perchance, it has not, to remove what is left will be an easy matter.

Scars.—A scar cannot be wholly removed; but a very bad looking scar may be greatly improved. It is the natural tendency of cicatricial tissue to turn white and contract, and to remove the deformity of the contraction, and to a degree the pearly whiteness is the object of the treatment. If the scar is elevated, it should be removed the same as an elevated nævus, and the same laws governing the selection of the poles should be applied. But those scars which are depressed and have contracted lines running through them require somewhat different treatment.

The treatment consists of a combination of negative punctures and dry cupping. First, all the contracting edges should be punctured with a fine needle connected with the negative pole. There should not be the same amount of tissue destroyed that is necessary in operating on port wine marks; only the slightest eschar should be made. We depend as much upon the osmotic effect by the setting free of bubbles of hydrogen, etc., to break up the tissue, as we do upon the formation of new tissue. After the scar has been scarified in this way, a dry cupping instrument is placed over it and slight suction made. This is for the purpose of drawing blood to the parts which increases the size of the vessels, and, consequently, increases the nutrition to the parts. At first this treatment may be given once a week or even oftener, and, as the scar improves, the intervals may be lengthened until once in three months may be sufficient to keep the scar thoroughly suffused with blood.

In hypertrophic cicatrices (Keloids) Drs. Derville and Becue in a number of cases have had good results from the static spark. The seance lasts from five to ten minutes and is re-

peated every fortnight. Three or four treatments in recent cases bring about softening and a diminution of elevation.

Acne Rosacea.—Electrolysis has been used successfully for the treatment of this very stubborn disease. The purpose of the treatment is to destroy the enlarged blood vessels, and consequently to cut off the circulation. This is easily accomplished, so far as destroying the blood vessels is concerned, but the complete operation is long and tedious. The positive pole is placed on any part of the body, while the negative is attached to a handle containing a large, thin, sharp-pointed jeweler's broach, and is threaded through the blood vessels, if that is possible. If it is impracticable to work the needle through the blood vessels and produce electrolysis of the vessels all at once, the vessels should be cut off at frequent points by producing electrolysis transversely across it. The treatment should be of sufficient thoroughness to entirely cut off all circulation through the vessels. The negative pole does not produce a firm clot and circulation is easily re-established; consequently, if a vessel is only partially destroyed at one or two points, circulation will be re-established, as mentioned in the removal of nævus. Four or five ma. will be required or may be used, and from one to two minutes may be necessary with each puncture. In order to do the work thoroughly, a small patch may be taken each day. Care should be exercised not to produce too much destruction at one sitting, or to have the sittings follow each other too closely, for these tissues are easily inflamed and congested, and are apt to be temporarily very much worse. The operation is more painful than the removal of hairs; therefore it is well to introduce the needle before the current is turned on, and then gradually turn on the current.

Eczema.—This multigenerous disease at last bids fair to become amenable to treatment through the agency of the electric current. Recent experiments with the high frequency currents, in the United States and in France, have shown remarkable results in almost all varieties of eczematous inflammations. The high frequency electrode, as recommended by

Oudin, should not remain over 3 to 4 minutes at one spot, and the whole surface affected should be treated successively during one seance. Treatment should be repeated every other day for a week and after that the patient should be frequently seen to watch the progress of the case. In inveterate cases persistent treatment is required. The proper hygienic and dietetic measures so essential in the treatment of this affection, must, of course, be properly enforced.

Gautier and Larat claim remarkable results in the treatment of nearly all varieties of eczema by means of the electric bath, with sinusoidal currents. Their technic is as follows: The patient is placed in a bath-tub, with water at 98–100 F., in full-bath position so that the currents affect the entire body. The poles of the sinusoidal current are then connected to the head and foot of the tub. The intensity of the current should vary from 25 to 40 ma. and its voltage from 30 to 40 volts. Treatment should consume 25 to 40 minutes, depending on the constitution and tolerance of the patient. In some cases it is necessary to give milder and shorter applications gradually increasing to the standard figures as given above. The treatment is usually followed by a feeling of lassitude and weakness, but a short rest quickly restores reaction. Two or three seances sometimes suffice to bring about a cure, but relapses have been noted in a few cases, which, however, were again rapidly cured by resumption of the treatment.

Psoriasis.—The high frequency current has been employed by Oudin in the treatment of psoriasis and his reports show gratifying results.

The electrode is placed for half a minute over the lesions, producing first paling of the surface followed by an erythematous glow with subsequent clearing of the skin, which, however, requires some time to regain its normal appearance.

Lemoderma—Vitiligo.—Larat has treated several cases of vitiligo by means of the electric bath with sinusoidal currents. In every instance the disease was checked and in some patients improvement followed after persistent treatment. The latter was treated every other day for several months and returned

from time to time to receive subsequent treatments in order prevent possible relapse.

Pruritis.—Pruritis, especially of the anus and of the vulva, has been repeatedly cured by the static breeze and recently the high frequency current has been tried in an inveterate case of prurigo with marked success. Recent lesions are cured in a few seances, while inveterate cases require extended treatment. Further experimentation will be required to demonstrate the exact sphere of this new current in the treatment of skin diseases in order to determine whether its action is due to germicidal, sedative or nutritive properties or to all combined.

Tinea, Favus, Sycosis, Etc.—Electricity has been used for its cataphoric effect in those diseases of the skin which are produced by vegetable parasites. There is undoubtedly a great field open for this form of treatment, but experience in it is as yet very limited. The most that has been accomplished is in treating various forms of tinea. The cataphoric action of the current is used to carry the bi-chloride of mercury into the tissues, and thus destroy the parasites. It is claimed by some that this is a very painful treatment, but we have been unable to find anyone asserting this who has mentioned the fact of having a milliampere meter. They have gone by the number of cells and compare the treament with an ordinary operation. Now, even a one to two thousand solution of bi-chloride of mercury is a much better conductor than water. When it is placed on the positive pole chlorine is greatly increased and set free, and this, as is well known, has a very irritable effect upon the skin. The method of treament is simple. Placing a large electrode beside the part to be operated upon, after the spot has been cleansed, the cataphoric electrode is filled with absorbent cotton, or, better still, with antiseptic gauze, and saturated with the solutions. A current of at least 8 or 10 ma. should be given for five or seven minutes. If the current is weaker than this it should be increased gradually in length of application.

Herpes Zoster.—This disease has long been a trying one. To

be sure, most cases are self-limited, running from one to two weeks, but in many cases they are not and the neuritis continues until finally it becomes quite chronic in a neuralgic form, making the life of the patient miserable. The disease may be of peripheral origin, beginning in the peripheral nerve or in the ganglia of the nerve roots. Generally speaking electricity will be used in two conditions; one during the severe pain just before the eruption comes out, and the other in the severe pains which follow the disappearance of the eruption, and may be due to a slight neuritis, or be purely neuralgic. In two cases of localized and not severe herpes which we treated with the static wave current, the patient was much relieved, and the eruption came out within a few hours after the first treatment.

It is claimed that the high tension faradic current is good for this condition, and recent experience with the high frequency current monopolar application with the vacuum glass electrode has led us to believe that this treatment will surpass any other form of electrical application. After the eruption has disappeared and there remain the neuralgic pains, it is a question what to use. The pathology of the case must be carefully studied. If it is purely neuralgic without any degeneration of the ganglia cells, the high tension faradic, the static breeze, static wave current, or high frequency current may be of great use. Any one of them may be indicated; if one does not relieve the other might be tried; in fact, we have had cases in which we have gone from one to the other and finally found one which gave almost instant relief. We cannot give indications which one to use; but we believe that, generally speaking, the light static spray or high frequency current will be found to give relief. As an illustration of how it is necessary to build up the ganglia cells in order to relieve these neuralgic pains, we report the following case, which perhaps more properly comes under another section but which, owing to its unique character, we give here.

The patient was a gentleman about fifty-five years of age. He suffered from a very severe attack of the so-called grippe

in March, and was confined to his bed for three weeks. During the stage of recovery he was attacked with a severe burning pain in the left side of his chest, including the area between the fourth and sixth intercostal spaces. Two groups of vesicular eruptions broke out, one near the spine and the other near the sternum. Instead of running the usual course, the pain continued and even grew worse. It was mostly of a burning character, but there would be intermittent paroxysm of lancinating pains through the parts. Throughout the summer the patient was treated with medicine. He went to the mountains and did all in his power to improve his general condition, but with no abatement of the pain. We first saw him on September 1. At this time his general health was good. The vesicular eruption had given place to a deep red papillary eruption. All medicine was discontinued. At first we passed a weak stabile galvanic current through the affected parts. Relief was experienced for a few moments; but the pain soon returned with increased vigor. The next day a faradic current was tried and considerable relief of the intermittent paroxysm followed. This treatment was continued daily for about ten days. The relief it produced seemed to reach a certain point and then stopped. For an hour or two after the treatment no discomfort would be apparent, but after that the pain would begin to return; and by night the patient would be suffering terribly, although not so bad as before the treatment was begun.

After two weeks' treatment with the faradic current, we resolved to try the effect of passing a galvanic current through the spine. Our idea in so doing was to direct nutrition to the posterior spinal roots and the ganglia connected with them. A large hand electrode (negative) was placed over that part of the spine corresponding with the location of the disease, and the positive, a similar electrode, was applied to the sternum. A current of from five to ten milliamperes was passed for eight minutes, when the positive was removed to the cervical region, and the same strength of current passed for five minutes. During this treatment the only apparent

improvement was a slight lessening in the burning pain; with this exception it remained about the same as when the faradic current was used. This treatment was repeated daily for ten days. We now returned to the faradic current. Almost immediate relief followed; and, after two weeks' treatment, all the burning and paroxysmal pain had disappeared.

Lupus Vulgaris.—It is generally conceded now that lupus vulgaris is due to tuberculosis. It has long been a much dreaded disease and one ill understood. The only electrical treatment that was found to be useful was the galvano-cautery; and this is still used by many physicians. If it is undertaken, there should be complete destruction of the lesion. If the surface is small this is not so great an undertaking; but when it is very large, for instance covering a considerable part of the face, it is a serious affair. The X ray, however, has for some time been found to have most decidedly beneficial effects upon lupus. The method of application is to apply the X ray to the part so as to get the so-called X ray burn. This not only destroys the disease quickly, but destroys the tuberculous bacillus.

In order to protect the healthy tissue, a large piece of sheet lead is placed over the surface where there is danger of the X rays coming in contact with the skin. An opening corresponding in size and shape to the lupus is made through the lead so as to allow the rays to concentrate themselves on the diseased area. Dr. Geyser, of New York city, has had phenomenal success with the static breeze. He found that while the X ray proved very successful in lupus vulgaris that it caused an alarming destruction of tissue. This was also the experience of Dr. Hills Coles, of Hartford, who was obliged to stop treatment occasionally on this account. Dr. Geyser substituted the static breeze for the X ray and found that improvement continued without the destructive effect.

Weil reported to the Paris Congress in the summer of 1900 a series of cases in which lumpus was treated by the static induced current; he exhibited a case of lupus of the face first treated in this way on May 29, 1899, which was cured by De-

cember of the same year. Schall thinks that success in the treatment of lupus by X rays lies in using low frequency interruptions, and a low voltage to energize the coil, 40 to 60 interruptions per second being all that should be used for maximum effects, and if electrolytic interrupters are employed 25 to 30 volts being all that is used to actuate them. He believes that the success of the treatment lies in setting up neuritis of the nerve terminations. He cites a case in which he did not succeed when his coil was energized with rapid interruptions; but when the interruptions were cut down progress was rapid.

Just how the X ray acts on lupus vulgaris is as yet unknown since very little is known regarding the nature of these rays. It is probably due to some chemical action which they possess. With the static breeze the ozone which is produced by it very likely plays an important part; Dr. Geyser's statement that the static breeze appears to act better on completely denuded surfaces would seem to bear out this theory.

SECTION NINE.

General Diseases and Diseases Not Otherwise Classified.

Rheumatism.—In this place we shall consider articular rheumatism (acute and subacute), rheumatoid arthritis and gout; sciatica and muscular rheumatism have been treated in another place.

With the inflammatory stage of articular rheumatism we have nothing to do. We are aware that some have claimed great success with the faradic current of tension during the inflammatory stage. We must admit, however, that we have never secured permanent benefit in treating any acute inflammatory affection with this current. Those who advocate the use of it admit that they cannot demonstrate that it contracts the blood vessels or in any way relieves the congestion permanently, or, for that matter, temporarily, but that it only produces a temporary anæsthesia which, at the best, is of short duration. After some recent experiences with the high frequency current we believe that it might be used in the inflammatory stage, providing it be very weak and the vacuum electrode be employed.

The time for electrical treatment to begin in acute articular rheumatism, so far as the galvanic or faradic currents are concerned, is after the acute inflammation has disappeared. There comes a time in the history of these attacks when the temperature falls to one or two degrees above normal; and the excessive sensitiveness disappears to such a degree that a slight

even pressure may be borne on the sensitive parts, such as the pressure of the electrode; the swelling decreases, and the pain is moderate when the limb is kept quiet, but painful when the joint is moved. If the previous inflammation has been slight and of short duration, so that there has been no plastic deposit, or if there has been no destruction of the tissues of the joint, recovery will follow rapidly under good hygienic conditions and the proper medical treatment, electricity not being called for. But it is in those cases where such a happy result is not achieved that electrical treatment should be given. Here we need the action of the galvanic current to break up the deposit into its several constituents, the atoms of which are rearranged to form new molecules and thus become absorbed. We need, also, the catalytic action and the stimulating effects of the current on the shattered nerve filaments, bringing them back to their normal action and thus relieving the pain. Faradism and Franklinism may possess some of these qualities, but they are lacking to a degree in many, and in some of the most important their action is *nil.*

The technic in the treatment of these cases is important. To simply pass a current through the affected joint, irrespective of the strength and manner of its passage, is not sufficient. As the knee is the most common joint attacked by rheumatism we will take that to illustrate the treatment. If the joint is very sore and tender, it is best to pass a current from above to below the joint. This is done by placing the large, flat, positive electrode about six to eight inches above the knee, and with a flat hand electrode, beginning six or eight inches below, give labile applications up over the knee, the treatment to continue for from eight to ten minutes. These treatments may be given daily or every other day, using from five to ten milliamperes.

The excessive soreness and tenderness will decrease rapidly under this treatment, and after about a week or two, at most, treatment can be given direct through the joint. For this it is necessary to use large electrodes, so that a considerable quantity may be passed, and also be distributed through the joint.

The electrodes should be thoroughly wet in hot water and applied to the knee a minute before the current is turned on so that the skin will become moistened, allowing the current to pass smoothly and evenly through the joint. In order to keep the electrodes warm, a large bath towel should be passed around the knee and electrodes. It is best to begin the first treatment with about eight to ten milliamperes, but as the inflammatory symptoms disappear, fifteen to twenty milliamperes may be passed. The current should be given stabile for ten minutes, and then with labile applications for a few miuutes over the joint, using the negative electrode, the positive being placed on the thigh above.

We have never appreciated the necessity of treatment of the tissues immediately surrounding the diseased area. It is very essential that the blood-vessels be acted upon through the vasomotor nerves at these points, so as to equalize the circulation and increase the nutrition of the parts. There are cases in which after the deposit has been absorbed and circulation has resumed its normal condition the pain still continues and causes suffering to the patient, showing that the nerves are not as yet in a healthy condition. We have recently had some excellent results with the high frequency current in two cases of this kind.

When there are several joints affected, or in that chronic or subacute form where there is some constitutional element involved in the cause of the rheumatism, local treatment is not all-sufficient. Here, along with the local applications general treatment for the constitutional effects should be considered of as much, if not of more importance. It is here that general faradization is of great value or, better still, the static application. Use first the static spark along the spine; this of itself, is a great tonic to the nervous system; then proceed to give the static breeze over the entire body. The general constitutional symptoms will greatly improve under this treatment. The pallor disappears and a ruddier complexion takes its place, showing the good effect of the treatment on the blood. The appetite improves, the nervous system becomes stronger,

muscular strength is increased, showing an increase in nutrition, and along with this improvement the rheumatism will disappear.

Larat, strongly recommends the use of the electric bath with sinusoidal currents in the treatment of subacute and chronic rheumatism. His cited cases show remarkable results, many intractable and supposedly incurable cases being rapidly ameliorated and cured by this method. The technic is as follows:

The patient is immersed in a bath of 95° to 98° with poles attached to the feet and dorsal portion of the spine respectively, the intensity being regulated so as to merely produce slight contractions. The first seances should consume about ten minutes,—in obstinate cases twenty to thirty minutes,—treatment being called for daily or every other day. If any particular region is specially painful or proves intractable one electrode is placed there for a short time and the treatment resumed as before. The proper dietary and hygienic regime must, of course, be also adhered to.

Rheumatoid Arthritis.—In the treatment of the disease known as rheumatoid arthritis, success has not been, in previous years, very marked; however, with improved apparatus, we are now able to do something with it.

At a recent meeting of the National Society of the Electro-Therapeutics, Dr. Frank A. Gardner exhibited an electrode with which he claimed to have had marked success in this disease. It consists of a glass jar, which has a metallic plate on the inside, with a connection for attaching the rheophore. This he fills with clay, which he keeps in a semi-solid consistency. Into this he thrusts the fingers, and allows a strong current to pass for some minutes. We have had but little experience with this method. We would suggest as an improvement on it, the painting of the skin just over the nodules with iodine, thus decreasing the resistance at that point and causing a concentration of the current on the nodules direct, while at the same time the surrounding tissues receive a sufficient amount to influence the circulation.

We have, however, recently had excellent success with the

cataphoric method of treatment. This consists of immersing the hands in a lithia bath, made by dissolving ten grains of lithia or the benzoate of lithia in a pint of water. Good sized finger bowls will answer the purpose admirably, and any kind of a metallic electrode may be used to connect the water with the conducting rheophore connected with the positive pole. The hand not to be treated is immersed in a saline solution in the same way, and connected with the negative pole.

After the nodules have been thoroughly painted with iodine the hands are immersed and a current of eight to twelve milliamperes passed for about as many minutes. When the joints of both hands are affected, the bath may be changed and each hand receive one-half of the treatment, as the seance should not be prolonged nor should treatment be given oftener than three times a week. It has been vigorously denied, that the absorption of the lithia produces the good effects that result, but that these are due to the stimulation of the current which is aided by the presence of the alkali. We do not propose to be drawn into this controversy, but we believe that the absorption has at least something to do with the results. A few weeks' treatment of this kind will, with recent cases, relieve the pain, lessen the redness and sometimes reduce the deposit.

Dr. Snow claims to cure these cases with the static wave current. He wraps the entire hand in tin foil, especially the diseased joints, and gives a charge just short of enough to produce muscular contractions, for twenty minutes. When the tin foil is removed the hand will be found covered with a slight perspiration. He skiagraphs the joint and if he finds the cartilages have not been in any way destroyed he promises a complete cure, but if they have become affected, he promises relief of symptoms only.

We have recently had some very marked results in some chronic cases of rheumatoid arthritis with the high frequency current.

Gout.—It cannot be said that electricity has had any material success in gout. After many trials, and with many methods,

we have never seen any material reduction of gouty deposits from its use. There are, however, some conditions of gout in which electricity may prove of benefit, as an adjunct to hygiene and medication. Those who have suffered long or much with gout, and have taken much of the anti-gout medicine, especially colchicum, are apt to get into a neurasthenic condition, and this has a tendency not only to increase the frequency of attacks but to prolong the period of recovery. The term "nervous gout" is sometimes applied to this condition. A general treatment, with the static breeze or general faradization, will improve the tone of the patient and will have a tendency to lessen the frequency of attacks. With the acute stage of gout, like rheumatism, electrical treatment is not indicated. But there comes, in certain chronic cases, a subacute condition when the acute inflammation subsides, leaving a soreness which interferes with locomotion. We have seen some very good results from a saline or a lithia foot bath, after the manner recommended for rheumatoid arthritis above. Our best results, however, have been attained, particularly when the deeper joints of the foot are affected, by first painting the top of the foot with iodine and then placing the negative pole over the iodine and the positive on the bottom of the foot. We here get the stimulation of the current, aided by its cataphoric action, and the counter-irritation from the iodine. To prevent the foot from becoming sore, a new spot should be chosen, from time to time, for the iodine. Not more than six or ten milliamperes should be passed, and treatments may be given twice and perhaps three times a week, if the foot bears it well.

An alternating treatment of electrical baths (sinusoidal current) with lithia foot-baths is used by Larat in gout. First he applies the electric bath for from 20 to 25 minutes. The next day he employs localized lithia baths for from 40 to 60 minutes with current strength of from 20 to 40 ma., according to the tolerance of the patient. The positive pole is placed over the affected joint while the negative envelops the limb surrounded by layers of cotton soaked in lukewarm water.

Adenomata.—The treatment of enlarged glands by electricity has long been practiced, but it is not to-day a particularly popular method, as surgical enucleation is much quicker and, as a rule, is much better. If the gland is small and is still movable, showing no adhesions, electrical treatment may possibly reduce it, and thus avoid a scar, which is of considerable importance if it should be in an exposed part of the neck or face. The mere passage of the galvanic current through a gland has very little if any effect upon it. The only method which is at all successful, and even the prognosis must be guarded with this treatment, is the carrying of iodine into the enlarged gland by means of the cataphoric action of the current. It should be remembered that iodine goes from the negative to the positive pole; therefore, the cataphoric electrode should be attached to the negative pole, and the positive pole placed directly opposite, so that the current passes directly through the enlarged gland. One great trouble with this form of treatment is that electrolysis of the surface is very apt to occur if a strong current is used. However, ten milliamperes continued for six minutes once in two weeks may be given without doing any damage. If, however, the gland does not reduce after three or four treatments, it will be useless to continue longer.

To puncture an enlarged gland and produce electrolysis of its substance is not a successful method of reducing it, unless the electrolysis be carried to the point of producing suppuration, which it is very prone to do. The point of entrance of the needle always furnishes excellent drainage, and when suppuration is once produced it will go on until the gland is entirely destroyed. This is not an exactly scientific method, but it has one advantage and that is the scar remaining is very small, being limited entirely to the point of entrance of the needle.

Tumors of the Mammary Gland.—With a well defined fibrous growth of the mammary gland, electricity is not indicated, as it will not accomplish sufficient to warrant its use. There are, however, ill-defined fibrous patches seemingly due to a mat-

ting together of the lacteal tubes from a fibrous exudation, which may be very easily removed by the simple passage of a galvanic current through them. The treatment is simple. It is only necessary to get the fibrous mass near and between the electrodes so as to secure the direct polar action on them. It is best to use the negative pole, when one is to be placed on the back, but it is possible at times to so place the electrodes on the sides of the breast that the fibrous mass will come directly between them. Fifteen or twenty milliamperes may be passed for ten or fifteen minutes, providing the electrodes are of sufficient size, the flexible hand electrode being preferable. Here again the cataphoric action of the current in carrying iodine into the mass, as given above in adenomata, may be very useful. The breast should never be punctured with a needle for electrolysis.

Ulcerations.—Some very severe ulcerations, which have baffled all other methods of treatment, have been cured by electricity. Strange to say, these cases have come from different sources and the practitioners have all used different methods of treatment. One uses the static spray entirely. Here we get a certain amount of ozone and free oxygen, the germicidal and stimulating effect of which is well known. Another uses the high frequency current. It is probable that this acts very similar to the static spray. A third uses an electrode saturated with a solution of salt water, to which is attached the positive pole and this is placed directly over the ulcer. This method of treatment is best carried out by saturating some absorbent cotton with a saline solution, and packing the ulcer thoroughly with it. Over this is placed a metal electrode. Here we set free a hypochloride, and as hydrogen has a greater affinity for chlorine than it has for oxygen, the watery substances are broken up, the hydrogen going to join the chlorine, leaving a free oxygen, which, of course, has a great germicidal and stimulating effect. Others use over the ulcer a platinum electrode to which is attached the positive pole. Here again we get chlorine, acids and oxygen. The oxygen does its work the same as before. So it appears that no matter what may be

the method employed, we come in each instance to the germicidal and stimulating qualities of oxygen as the beneficial agent.

Disease of the Joints.—There is probably no field in which electricity is more useful than in certain diseases of the joints. It should not be used in tubercular conditions, nor is it of any use in acute inflammatory conditions. But after the acute inflammation from dislocations, sprains, bruises, etc., has passed away electricity finds its best opportunity. We have here two things to accomplish, first, to cause absorption of any deposit which may have been thrown out by the inflammation, and second, to repair the wasted tissue by building up the circulation and increasing the nutritive fluids, thus bringing about a healthy action of the injured nerve filaments. The best method of accomplishing the first result, that of absorbing the fibrous deposits, is to pass a galvanic current directly through the parts. (For further details of this procedure we refer the reader to articular rheumatism.)

The galvanic current, or even the faradic current is very inferior to the static in removing those symptoms which are the result of injured nerve filaments, such as pain, soreness, stiffness and anasarca. The static is best given with very light sparks from the wooden ball, or with the breeze from the brass point, but even this is inferior to the high frequency current given by means of the glass-lined electrode. We have recently treated a case of sprained joint of long standing, where the distress and pain and tightness had lasted for more than two years. The galvanic was tried with the idea that perhaps some deposit was pressing on the nerve filaments, but without success. The faradic was tried with the same result. The static breeze relieved the pain and soreness slightly and entirely removed the anasarca. Five treatments of the high frequency current removed all the other symptoms, and the patient was able to walk without pain and soreness for the first time in two years. The method of treatment was to use the glass-lined electrode, giving about a half inch spark until the surface became quite sore.

Cancer.—Almost from its first use in medicine, electricity has had its advocates for the cure of cancer. About ten years ago Dr. J. Ingalls Parson, of London, instituted a method in which he used a slow alternating current placing both electrodes into the cancerous mass and producing severe shocks through the cancer, claiming thereby to destroy the cells, as their vitality being much less than a healthy cell would be destroyed by this shock, while the normal cell would withstand it. While this treatment produces a slight action upon cancerous cells there can be no doubt that the action is limited and, according to our experience, is not sufficient to cure the cancer. More recently Dr. Massey, of Philadelphia, has instituted a treatment by which he carries mercury into the mass of the cancer by the cataphoric action of the current, claiming that this destroys the cancerous cell. With small growths he simply amalgamates the electrode which he introduces into the cancer and to which he attaches the positive pole. With larger growths he uses a hollow needle through which he injects the mercury and carries it into the tissues in the same way. The idea of the hollow needle is that more mercury can be carried into the tissues. With this treatment we have had no experience. If electrolysis be performed in a cancerous tumor, according to our experience, which is based upon the treatment of seventy-five cases, the tissues begin to immediately break down, a discharge will be set up, and the patient will decrease in strength in about the proportion of the breaking down of the tissues. In fact it hastens the end.

Of late the X ray has been brought into practice, and apparently at least, gives promise of some good results, especially in those cases of large glandular involvement where the knife cannot well be used. The method employed is to cover all the surrounding healthy tissue with a sheet of lead, in which is made an opening corresponding in size and shape to the area of the diseased tissue. The X ray is passed for about ten minutes twice a week. If there seems to be too great destruction of tissue it is not passed so often, and if on the other hand this amount of X ray does not seem to affect the tissue

it is given much longer and more frequently. The subject of treating cancer with electricity is very uncertain as yet. At the present stage electricity should not, in our opinion, be employed in those cases where the knife can be used with any degree of certainty. We know that we are here taking opposite ground to some enthusiastic electro-therapeutics, but nevertheless such has been our experience.

Chamberlain reports, with photographs, a number of cases of epithelioma treated successfully with the X ray. High vacuum tubes were employed, the distance from the lesion treated varying from 3 to 10 inches, preferably 4 to 5 inches, with six minutes' exposure. The frequency of the treatment varied from daily to twice a week until some effect had been obtained. This effect, in the case of an open sore or mucous surface, consisted in the appearance of an exudation, grayish in color, which when stripped off, left a bleeding surface. In the case of a skin surface, this effect consisted in the appearance of a redness described as being a form of dermatitis, which, however, was not accompanied by burning or itching. The effect referred to did not appear before the eighth day following the first treatment; in some cases it was delayed for three weeks; the average, however, was about the tenth day. As soon as either exudation or redness appeared, the treatments were reduced to three or four a week. As far as possible, the healthy tissue surrounding the growth was protected by lead rolled very thin, or four thicknesses of tinfoil such as is used by florists. When hypertrophic granulations were present, they began to melt away about the time the exudate appeared and a healthy line usually appeared within a month.

Williams has also reported several cases of epithelioma improved by X ray treatment, the tumor having been diagnosed by a competent pathologist. His cases were located on the lip and on the hand.

Aneurism.—A small superficial aneurism should be treated the same as a nævus, but an internal aneurism will require somewhat different procedure. It will be remembered that, when the two poles of a galvanic battery come in contact with

blood, a clot is formed around each; that around the positive is small, hard, and firm, while that around the negative is larger, softer and readily broken up. In order to get the best effect, we should introduce both poles in an aneurismal sac. This should be done so that the two will not be more than three-fourths of an inch apart. By so doing the clots around the two needles will join together at their edges. In this way we get the advantage of the large clot of the negative pole, and at the same time this is supported by the firm clot of the positive.

One method of operating is to introduce needles into the sac three-fourths of an inch apart until the sac is filled, and then attach every alternate one to the positive and the others to the negative pole. By this means we get the hard, firm clot of the positive on each side of a soft negative clot. Treatment should be continued until all signs of circulation in the aneurism have ceased and the tumor has become hard and firm.

The needles used should be thoroughly insulated with hard rubber, so as to protect the walls of the aneurism from the electrolytic action, for accidents have occurred from rupture of the wall of the sac when this precaution was not taken. Steel needles are, of course, used on the negative pole, but gold or platinum needles should be used on the positive; we are well aware that the clot would be materially larger if an iron needle were used here, but the difficulty of its removal makes it liable to detach the clot. The success attending this method of treating an aneurism is very good in the hands of a careful operator who understands electro-physics and electrolysis; but it is unsuccessful in the hands of the inexperienced operator.

The Moore-Corradi method for the treatment of aneurism of the aorta by the insertion of a permanent wire and the application of electrolysis is, at present, used with some success. The technic is ably described by Dr. Guy L. Hunner in a recent paper as follows:

"In his preparation for an operation the surgeon should ex-

periment beforehand with his needles, wire and electrical apparatus, to find which he can manage with the greatest facility and effectiveness. The needles should be considered with regard to size, material, insulation and sterilization. One chooses between the canula with trochar and the lance-pointed aspirator needle, which latter may be inserted alone or with the initial end of the wire already introduced. Within limits the needle should be large enough for the easy passage of the wire. The loss of blood, if the wire be inserted with the needle or soon after, is very slight.

As to insulation, the needle should be covered from the shoulder to within 1 c.m. of the point, with some non-conducting material, so that the electrical current will not be dissipated when the needle passes through the sac wall. The needles are neatly and most effectively covered with a black varnish or lacquer ('best French lacquer'). This cannot be boiled nor will it bear soaking in carbolic acid. It softens in the steam sterilizer either with or without pressure, but quickly hardens on exposure to dry air; so this method may be used. The best method is to sterilize in a dry air chamber. One should select a half dozen needles of various sizes and lengths; have them lacquered; place them in a test-tube, and cork with cotton. This is placed in a hot air chamber, the temperature raised to 160 degrees C., and allowed to remain there one hour. The test-tube is kept corked until time for the operation, when the needles are emptied out on a dry, sterile towel or plate. In selecting wire one considers the amount to be used, its size and its composition. The recognition of a few general principles will aid in its selection.

(1) The disposition of the wire in the lumen of the sac is an important factor in the amount and effectiveness of the fibrin whipped out. A small quantity of fine wire possessing a good spring should be selected.

(2) Cure of the aneurism demands as complete contraction as possible of the sac wall upon the clot formed at or soon after the operation. The wire should be of such amount and material as not to interfere seriously with this contraction.

(3) The corrosion of the wire by the electric current makes a rough surface very conducive to the rapid whipping-out of the fibrin. Within limits the wire most easily corroded is to be preferred. The wire found most serviceable by the operator is a silver alloy highly drawn; 75 parts of copper to the thousand makes a wire which when drawn from No. 8 to No. 27 (standard gage) takes a closer coil than steel. "It is more pliant than steel, thus minimizing the degree of puncture should the end come in contact with the thin aneurismal wall. It has more body than the pure silver of equal drawing, and is therefore more easily passed into the needle without kinking. It corrodes much more than steel, thus forming a rougher surface for the whipping out of fibrin. We believe, however, that the fibrin formation is far more a chemical than a mechanical process, and silver, being one of the least resistant of all metals to the electric current, transmits more of a given current for action on the blood."

The galvanic battery should rest on a table near the anæsthetist, and by means of its insulating conducting cords is connected—the positive pole to a long end of the wire from the aneurismal sac, and the negative pole to a metal plate at the back. This plate should be well covered with several layers of towel kept moist throughout the operation; 10 to 15 ma. for one hour has been found most efficient. "*Never should the sac receive both poles, nor should the current be so passed that the negative electrode is in the sac.* Duncan, and later Stevenson, have shown that about the negative pole there accumulates a yellow, friable, alkaline mass composed to a great extent of gas bubbles which very quickly break down, while about the positive pole the clot is smaller, firmer, and darker in color, and has an acid reaction.

In thoracic aneurism one of the greatest claims for this method over that of distal ligation is the fact, that the patient does not require an anæsthetic. This is particularly advantageous in cases of dyspnœa and bronchitis from pressure on the trachea. Locally cocaine or ethylchlorid may be used. Usually the needle is inserted where the sac-wall seems near-

est the exterior surface. If there be more than one point of bulging and it be suspected that a multilocular or very large sac is being dealt with, it would be advisable, as suggested by Stewart, to pass wires at more than one point and attach the positive pole to each. The needle should be inserted as nearly as possible with the direction of the entering current and away from the mouth of the sac. If a kink occur after some wire is in, insert another needle, and after passing the required amount of wire both wires are attached to the positive pole.

For the abdominal cases make the usual preparations for cœliotomy. Be particularly careful to clear the intestines in order to have the field of operation as free as possible. The method of exposure of the sac will have to be determined for the different organs, the adhesions present, the direction in each case according to the position of the sac, its relations to which the needle should be passed and other contingencies that arise after opening the peritoneal cavity.

Rachitis.—Sagretti and Tederchi and Larat report excellent results in the treatment of rachitis by means of the electric bath. The bath, preferably with sinusoidal currents should be given two or three times per week, for twenty minutes at a time with current strength of about 20 to 25 ma. After a number of seances the disease is arrested, the osseous deformities diminish and marked general improvement takes place.

The static spray also influences nutrition of rachitic patients very favorably.

Obesity.—While restricted diet and massage are still considered the main factors in the treatment of obesity, the vigorous application of the sinusoidal current or of the same current in combination with the bath have proven of exceeding value. The treatment should be mild at first, gradually increasing the contractions of the muscles to tolerance.

Cases in which fatty degeneration of the heart exist must be treated with very weak currents only and treatment stopped as soon as evidences of distress manifest themselves.

Chilblains.—The high frequency current, also the static spray have cured chilblains after a few seances, the circulation being rapidly improved and pain relieved almost instantly. Treatment should be given every other day for a week.

Mammary Glands.—In retarded development of the mammary glands electricity has been used successfully in many cases. Mild sinusoidal currents are preferably employed in conjunction with appropriate massage, and the parts, unless atrophied, are rapidly stimulated to increased nutrition and growth.

Asthma.—Electricity has been tried in this intractable disease with no appreciable success. Cases in which the spasmodic element is marked have had this symptom ameliorated. Rockwell recommends galvanization of the vagus. Erb commends faradization of the same nerve. When treating the pneumo-gastrics it is best to give equal attention to both sides at the same seance. Larat claims to have improved several cases of asthma by means of the static spray and the static spark applied over the thorax.

Diabetes.—Several cases of diabetes especially of the neurotic type have been markedly ameliorated by general faradization and central galvanization. As a rule, however, electricity has no decided action on the course of the disease. Apostoli claims to have cured a number of cases by means of the high frequency current and this new potent agent deserves further trial in this disease. Static electricity has served to ameliorate intercurrent symptoms of the neurotic type and improved the general metabolism of the patient but has seemingly no effect on the glycosuria.

One case of diabetes which we treated with galvanism for paralysis of the lower extremities, by placing the positive pole over the back and the negative over the motor points of the lower extremities causing vigorous contraction of the muscles, the sugar disappeared and did not return during the remainder of the patient's life, which, unfortunately, was but a few months, death being due to pneumonia.

Asphyxia—Suspended Animation.—Stimulation of the phrenic nerves in the neck has frequently resulted in setting up res-

piratory movement through action on the diaphragm, etc. At the same time, stimulation of the epigastrium should also be tried in order to produce expiratory movements through action on the abdominal musculature. These methods may be employed while the other usual means for inducing artificial respiration are being tried. The stimulation of the phrenic nerve should be about every five or ten seconds.

Chlorosis and Anæmia.—Chlorosis and anæmia have been successfully treated with the electric bath with sinusoidal currents combined with the usual dietetic, hygienic and medicinal adjuvants. The reaction produced by the stimulus of these baths is such, that the appetite is improved and the circulation soon restored to its normal state with rapid amelioration of all symptoms. Catamenia again becomes normal and with proper diet marked increase in weight will be noted.

Diseases of the Heart.—In the past few years many observers, notably Larat and Sagretti have applied electricity with excellent success to the treatment of certain cardiac diseases. The methods employed are all practically the same, the efforts being directed to an improvement of the capillary and general circulation thus relieving a non-competent heart from part of its burden and permitting it to recuperate.

It is, of course, impossible to change a marked valvular lesion, but whenever the heart muscle itself or its innervation is at fault, electricity has been found curative in many cases hitherto unresponsive to treatment.

The treatment consists of a course of baths with sinusoidal or faradic currents. The action of these electric baths, if properly given, is to improve the general circulation, especially the peripheral, diminish visceral congestion and increase diuresis.

Improvement is usually noted after a week's treatment and marked amelioration, with diminution or entire removal of anasarca, has been accomplished after a dozen or more seances. The baths are contra-indicated in marked anteriosclerosis and advanced myocarditis. The technic is as follows:

The patient is placed in an insulated bath-tub with water at

95°–98° F. One pole is attached to the head and the other to the foot of the bath-tub, and the current is started mildly, the sensations or tolerance of the patient being the best guide for an increase or decrease of the current. With experience, the operator can regulate the current so as to conform with the rhythm of the heart, which is an important desideratum, for stimulation by electricity given at the improper cycle is apt to produce irregularity in the contraction of the heart muscle, instead of assisting its action. As a rule, bathing is not well tolerated by patients with cardiac lesions but with the electrical adjunct, the stimulus immediately improves the capillary circulation with usually prompt relief of oppression and dyspnœa; respiration becomes easy, and pain when present, is diminished or entirely relieved.

The first few seances should be of short duration, say from 8–10 minutes, and should be gradually increased until the patient becomes accustomed to the treatment and will readily tolerate a seance of 20 minutes. Baths should be given preferably every other day and in the morning.

In some cases, which failed to respond to digitalis, adonis, strophantus, cratægus and other favorite drugs having special cardiac action, a course of baths so reconstructed the patient that favorable action of the remedies was quickly noted when they were prescribed subsequent to the treatments.

The baths undoubtedly produced mechanical relief for the heart, as the resistance which the organ must overcome is lessened by the excitation of the vasomotor nerves through elecrical stimulus. The capillary circulation is restrained and prolonged and the muscular coats of the smaller vessels are through electrical massage, invigorated and regenerated, thus improving their contractility. The capillary circulation again becomes vigorous and restored to function, and the central organ being relieved of its excessive burden performs its function with more ease and regularity.

In addition, the slow contraction of the muscles of the whole body through the electrical stimulus produces a general massage, with increased intra-muscular as well as general circula-

tion. The action is practically the same as the abdominal massage and reflexes employed with success in certain cases of heart disease, but the hydro-electric treatment is more certain, less irritating and decidedly more agreeable as compared with the other. An examination of the Nauheim methods of treating heart disease will show, that their results are based on the same physiological principles as are involved in the application of electro-hydriatrics.

INDEX.